SYSTRON DONNER

154-4

GENERAL INFORMATION

Pulse Generator

GENERAL INFORMATION

GENERAL
INFORMATION

INSTRUCTION MANUAL

MODEL 153/154-1 and 3
PROGRAMMABLE PULSE
GENERATORS

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SYSTRON DONNER CORPORATION

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SYSTRON DONNER
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MODEL 153/154 PROGRAMMABLE PULSE GENERATORS

The Model 153/154 digitally programmable pulse generators are designed for use in automatic systems for the testing of integrated circuits and other solid state devices. Front panel controls on Model 153/154–1 allow for their use in conventional pulse generator laboratory applications. These instruments operate at repetition rates up to 50 MHz, delay and width up to 10 ms, transition times less than 5 ns and amplitudes up to 10 volts. All parameters, repetition rates, delay, width, upper and lower voltage levels (amplitude) pulse polarity and transition times (Model 154 only) can be controlled from a remote programming source.

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TABLE OF CONTENTS

		PAGE
TITLE PAGE		i
FRONTISPIECE		iii
TABLE OF CONTENTS		v
LIST OF SCHEMATICS		vii
LIST OF FIGURES		vii
LIST OF TABLES		viii
SECTION I	**SPECIFICATIONS**	
1.1	Repetition Rate	1-1
1.2	Delay	1-1
1.3	Width	1-1
1.4	Jitter	1-1
1.5	Upper Level (V_{UL}) and Lower Level (V_{LL})	1-1
1.6	Transition Times (Model 154—1 and 3)	1-1
1.7	Waveform Aberrations	1-1
1.8	Accuracy	1-1
1.9	Output Protection	1-1
1.10	External Trigger Mode	1-1
1.11	Gate Modes	1-2
1.12	Double Pulse (Pulse Pairs) Mode	1-2
1.13	Output Complement Mode	1-2
1.14	Output Off	1-2
1.15	Trigger Output	1-2
1.16	Manual Control	1-2
1.17	External Programming	1-2
1.18	Programming Format	1-2
1.19	Programming Time	1-3
1.20	Operating Temperature	1-3
1.21	Power Required	1-3
1.22	Physical Characteristics	1-3
1.23	Accessories Furnished	1-3
1.24	Accessories Available	1-3
SECTION II	**CONTROLS AND CONNECTORS**	
2.1	Power	2-1
2.2	Rep Rate	2-1
2.3	Delay	2-1
2.4	Rise (T_+)/Fall (T_-) (Model 154—1 and 3)	2-1
2.5	V_{UL}	2-1
2.6	V_{LL}	2-1
2.7	Man Cont	2-1
2.8	Sync Gate	2-1

SECTION II (cont.)

		PAGE
2.9	Async Gate	2-1
2.10	Ext Trig	2-1
2.11	Trig Polarity	2-5
2.12	Dbl Pulse	2-5
2.13	Output Complement	2-5
2.14	Output Off	2-5
2.15	Output Connector	2-5
2.16	Trig Out Connector	2-5
2.17	Async Gate Connector	2-5
2.18	Sync Gate Connector	2-5
2.19	Ext Trig Connector	2-5
2.20	J1 and J2 Connectors	2-5
2.21	AC Power Connector	2-5
2.22	115/230 Volt Slide Switch	2-5
SECTION III	OPERATING INSTRUCTIONS	
3.1	General Instructions	3-1
3.2	Manual Control Operation	3-1
3.3	Remote Programming Control	3-3
SECTION IV	MAINTENANCE	
4.1	Preventive Maintenance	4-1
4.2	Parts Replacement	4-1
4.3	Calibration	4-2
4.4	Specification Verification	4-13
SECTION V	THEORY OF OPERATION	
5.1	General Description	5-1
5.2	Detailed Circuit Description	5-1
SECTION VI	PARTS LIST	
6.1	Abbreviations and Symbols	6-1
6.2	Front Panel Assembly	6-2
6.3	Auxiliary Switch Assembly	6-4
6.4	Front End PCB Assembly	6-4
6.5	V_{UL}/V_{LL} Control PCB Assembly	6-12
6.6	Variable Rise/Fall Power Supply (Model 154 only)	6-15
6.7	Variable Rise/Fall Output Amplifier PCB Assembly (Model 154 only)	6-17
6.8	Circuit Board Assembly—Fixed Rise/Fall Output Amplifier (Model 153 only)	6-22
6.9	PCB Assembly 150 Power Supplies and Regulators	6-25
6.10	PCB Assembly—Linear D/A Converter	6-27

SECTION VI (cont)

		PAGE
6.11	PCB Assembly—Hyperbolic D/A Converter	6-29
6.12	Hyperbolic Conductance D/A Converter	6-32
6.13	PCB Assembly Serial to Parallel Converter	6-34
6.14	Back Panel Assembly—150 Series	6-35

LIST OF SCHEMATICS

Drawing Number	Title
41000-230	Block Diagram—Model 153/154 Programmable Pulse Generators
40000-421	Schematic – Front End
40000-558	Schematic – VUL/VLL Control Circuit
40000-551	Schematic – Variable Rise/Fall Power Supply II
40000-436	Schematic – Fixed Rise/Fall Output
40000-438	Schematic – Variable Rise/Fall Output Amplifier
40000-481	Schematic – Linear D/A Converter
40000-482	Schematic – Hyperbolic D/A Converter
40000-550	Schematic – Hyperbolic Conductance D/A Converter
40000-483	Schematic – Serial to Parallel Converter
40000-486	Schematic – Program Distribution Parallel Input Digital
40000-487	Schematic – Program Distribution Serial Input Digital
40000-417	Schematic – Power Supply

LIST OF FIGURES

Figure Number	Title	
2-1	Model 153/154 Controls and Connectors	2-2
2-2	Parallel Programming Information	2-3
2-3	Serial Programming Information	2-4
3-1	Parallel Input Sample Program	3-4
3-2	Output Waveform Sample Program	3-4
3-3	Serial Input Sample Program	3-6
4-1	Model 153/154 – Top View	4-3
4-2	Model 153/154 – Bottom View	4-4
4-3a	VUL/VLL Control Circuit Adjustments	4-5
4-3b	Rise/Fall Power Supply Adjustments	4-5
4-4	Linearity Characteristics	4-17
4-5	Pulse Characteristics	4-20
4-6a	Rep Rate Jitter	4-20
4-6b	Delay Jitter	4-20
4-6c	Width Jitter	4-20
5-1	Waveform Diagrams	5-2
5-2	Rep Rate Multivibrator	5-3

LIST OF FIGURES (cont.)

		PAGE
5-3	Delay One-Shot	5-6
5-4	V_{UL} Range and Polarity Selection Circuit	5-9
5-5	Detailed Range and Polarity Selection Circuit	5-10
5-6	Simplified Block Diagram	5-11
5-7	Rise/Fall Output Amplifier Circuit	5-15
5-8	Hyperbolic D/A Converter	5-16

LIST OF TABLES

4-1	Repetition Rate Checks	4-14
4-2	Delay/Width Checks	4-14
4-3	V_{UL}/V_{LL} Range Checks	4-16
4-4	Rise (T_+)/Fall (T_-) Time Checks	4-18

SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

Variable from 10 Hz to 50 MHz in seven ranges. In the double pulse mode the repetition rate is limited to 25 MHz maximum.

1.2 DELAY

Variable from 10 ns to 10 ms in six ranges. Maximum duty factor is 70% for repetition rates below 10 MHz and 50% for repetition rates above 10 MHz. In the double pulse mode, minimum separation between pulses (measured between the trailing edge of the first pulse and the leading edge of the second pulse) must be greater than 30% of the pulse width or 20 ns, whichever is greater.

1.3 WIDTH

Variable from 10 ns to 10 ms in six ranges. Maximum duty factor is 70% for repetition rates below 10 MHz and 50% for repetition rates above 10 MHz. Duty factors to 100% may be achieved through the use of the complement mode.

1.4 JITTER

Repetition Rate, Delay and Width jitter are <0.05% or 200 ps whichever is greater.

1.5 UPPER LEVEL (V_{UL}) and LOWER LEVEL (V_{LL})

Independently variable between -10 V and +10 V at amplitudes between 1.0 V and 10.0 V. Maximum difference between upper and lower level settings is limited to 10 V.

1.6 TRANSITION TIMES (Model 154–1 and 3)

1.6.1 Variable Transition Times (Model 154 only)

T_+ (positive-going transition time) and T_- (negative-going transition time) are variable from < 5 ns to 10μs in four ranges and are independently variable within the same range. Linearity is ±5% above 10 ns and ±10% below 10 ns.

1.6.2 Fixed Transition Times (Model 153 only)

T_+ and T_- are fixed at < 5 ns.

1.7 WAVEFORM ABERRATIONS

Less than 5% of waveform excursion when output is terminated with 50 ohms.

1.8 ACCURACY

Accuracy is ±5% +1 ns of programmed value for all timing parameters and ±5% of programmed value for V_{UL} and V_{LL} >1 volt at 25° C. Accuracy is valid for BCD or thumbwheel settings between 100 and 999 only.

1.9 OUTPUT PROTECTION

The output is fully protected against damage from open circuit, short circuit to ground, programming errors and external voltages less than ±10 V.

1.10 EXTERNAL TRIGGER MODE

In this mode, the instrument can be triggered by an external source at repetition rates up to

50 MHz. The external trigger can be a positive or negative pulse but must have a minimum width of 4.5 ns and minimum amplitude of 1 volt. Input impedance is 50 ohms. The maximum level that can be safely applied is ±5 V.

1.11 GATE MODES

A +1 volt pulse is required to enable either synchronous or asynchronous gating. Input impedance is 50 ohms. The maximum level that can be safely applied is ±5 V.

1.11.1 Synchronous Gate Mode

In this mode, the output occurs only for the time interval of an externally applied gate pulse. The rep rate multivibrator is enabled by the gate pulse, therefore the output and the gate pulse are synchronized.

1.11.2 Asynchronous Gate Mode

In this mode, the output occurs only for the time interval of an externally applied gate pulse. The rep rate multivibrator is operating continuously in this mode, therefore the output and the gate pulse are not synchronized.

1.12 DOUBLE PULSE (Pulse Pairs) MODE

Two pulses per repetition rate period are generated at the output. The first pulse is coincident with the trigger output, the position of the second pulse is determined by the delay setting.

1.13 OUTPUT COMPLEMENT MODE

In this mode, the time positions of upper (V_{UL}) and lower (V_{LL}) levels are reversed. T_+ and T_- are also reversed in the Model 154 instruments.

1.14 OUTPUT OFF

In this mode, the output levels are at ground, however, the trigger output is uninterrupted.

1.15 TRIGGER OUTPUT

A positive pulse with a minimum amplitude of 1.2 volts, minimum width of 5 ns and a maximum T_+ of 3 ns when terminated with 50 ohms.

1.16 MANUAL CONTROL

Front panel thumbwheels and pushbuttons are provided for the control of all pulse parameters and modes of operation. T_+ (rise time) and T_- (fall time) are not variable on Model 153 instruments.

1.17 EXTERNAL PROGRAMMING

All pulse parameters (with the exception of T_+ and T_- on the Model 153–1 and 3) and modes of operation can be controlled from an external programming source. The logic levels for ground true instruments are 0 V for true (logical 1) and +5 V for false (logical 0). For positive true instruments +5 V is true (logical 1) and 0 V is false (logical 0).

1.18 PROGRAMMING FORMAT

No provision is made for synchronous programming of the timing parameters of this instrument. Therefore, the apparent programming time may be as long as the programming time (above) plus the sum of the period from which the program was changed and the period to which it is changed. If synchronous programming is desired, it may be accomplished by synchronizing the programming source to the sync pulse out of the generator.

1.18.1 Parallel Input (Model 153/154–1)

Format is BCD (8 - 4 - 2 - 1) ground true or positive true logic. Compatible with TTL and DTL logic. Eighty programming lines are required for Model 153 and 106 lines are required for Model 154. A true input enables the mode of operation (EXT TRIGGER, SYNC GATE, etc.) and range or vernier BCD bits.

1.18.2 Serial Input (Model 153/154—3)

Format is BCD (8-4-2-1) ground true or positive true logic. Compatible with TTL and DTL logic. Programmed by 12-bit characters entered serially. Thirteen lines are required to program the instrument, 12 address and data lines and one clock line. Ten 12-bit characters are required to fully program the Model 153 instruments and 14 are required to fully program the Model 154 instruments. A true input enables the mode of operation (EXT TRIGGER, SYNC GATE, etc.) and range or vernier BCD bits.

1.19 PROGRAMMING TIME

A maximum time of 100 μs for all parameters, except V_{UL} and V_{LL}. A maximum time of 3 ms for V_{UL} and V_{LL}.

1.20 OPERATING TEMPERATURE

15° to 45° C.

1.21 POWER REQUIRED

Approximately 200 W, 50—60 Hz at 105—125/210—250 V ac selectable by means of a multi-tap transformer and a range switch on the back panel.

1.22 PHYSICAL CHARACTERISTICS

The front panel has a brushed aluminum finish with etched and filled markings. All connectors are mounted on the back panel. Signal connectors are BNC type and programming connectors are Winchester Type MRAC755—J with Type 100—10205 removable pins. Weight is 28 pounds and shipping weight is 32 pounds. The dimensions are 19" W x 5¼" H x 20½" D for bench instruments.

1.23 ACCESSORIES FURNISHED

An 8-foot ac power cord with a 3-prong connector, two card extenders and one operation and maintenance handbook. All Model 153/154 Pulse Generators are rack mounted.

1.24 ACCESSORIES AVAILABLE

Model 150—2 Digital Programmer.

SECTION II

CONTROLS AND CONNECTORS

Refer to Figure 2 - 1 for the following description of controls and connectors. For external programming information for instruments with parallel inputs, refer to Figure 2 - 2. For external programming information for instruments with serial inputs, refer to Figure 2-3.

2.1 POWER

Turns the instrument off and on and illuminates the indicator lamp.

2.2 REP RATE

The thumbwheel on the right selects one of seven available repetition rate ranges and the three remaining thumbwheels continuously vary the repetition rate within the range selected.

2.3 DELAY

The thumbwheel on the right selects one of six available delay ranges and the three remaining thumbwheels continuously vary the delay within the range selected.

2.4 RISE (T_+)/FALL (T_-) (Model 154–1 and 3)

The middle thumbwheel selects one of four available T_+ (positive-going transition time) and T_- (negative-going transition time) ranges. The three thumbwheels to the left of the range selector continuously vary T_+ within the range selected and three thumbwheels to the right of the range selector continuously vary T_- within the range selected.

2.5 V_{UL}

The thumbwheel on the right selects one of four available upper level voltage ranges and the three remaining thumbwheels continuously vary the voltage level within the range selected.

2.6 V_{LL}

The thumbwheel on the right selects one of four available lower level voltage ranges and the three remaining thumbwheels continuously vary the voltage level within the range selected.

2.7 MAN CONT

Selects the method of controlling the output pulse parameters. When the pushbutton is depressed, the parameters can be controlled by the front panel controls. When the pushbutton is released, the parameters can be controlled by an external programming source.

NOTE: The MAN CONT pushbutton must always be in the released position when an external programming source is connected, otherwise erroneous programs will result.

2.8 SYNC GATE

Enables synchronous gating when the pushbutton is depressed.

2.9 ASYNC GATE

Enables asynchronous gating when the pushbutton is depressed.

2.10 EXT TRIG

Selects the external trigger mode when the pushbutton is depressed.

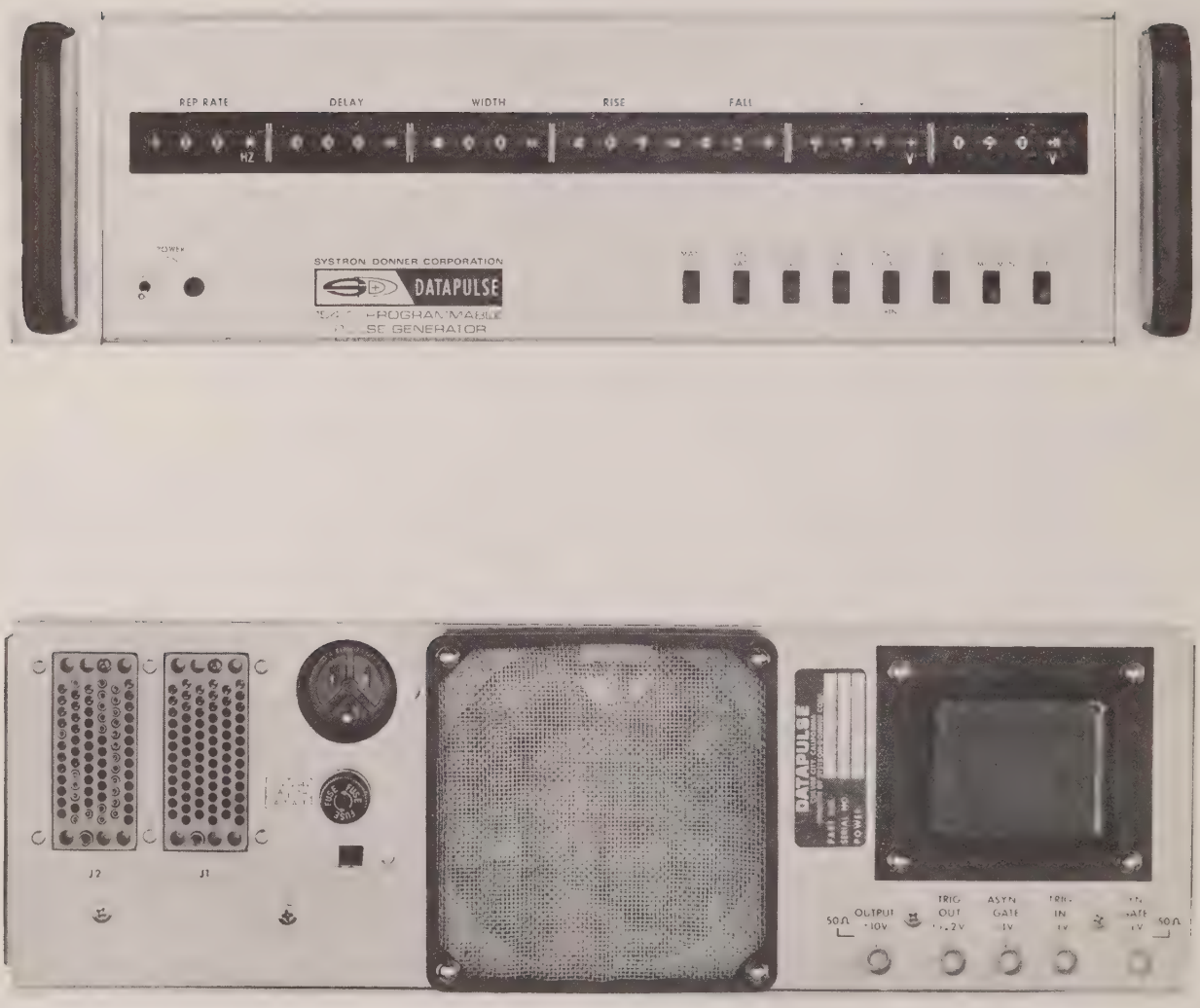
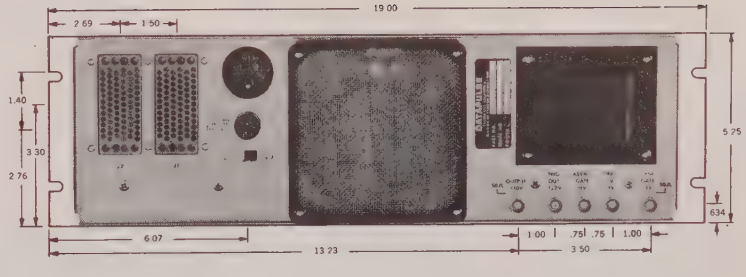


Figure 2-1. Model 153/154 Controls and Connectors

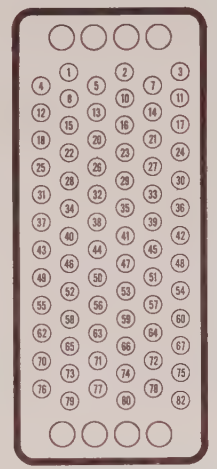
RNG #	REP RATE	DELAY OR WIDTH	V_{UL} OR V_{LL}	T_+ & T_-	BCD 1	BCD 2	BCD 4
0			−1 V to −10 V	5 ns to 10 ns	0	0	0
1	10 MHz to 50 MHz	10 ns to 100 ns	−0.1 V to −1 V	10 ns to 100 ns	1	0	0
2	1 MHz to 10 MHz	0.1 μs to 1 μs	+0.1 V to +1 V	0.1 μs to 1 μs	0	1	0
3	0.1 MHz to 1 MHz	1 μs to 10 μs	+1 V to +10 V	1 μs to 10 μs	1	1	0
4	10 KHz to 100 KHz	10 μs to 100 μs			0	0	1
5	1 KHz to 10 KHz	0.1 ms to 1 ms			1	0	1
6	0.1 KHz to 1 KHz	1 ms to 10 ms	V_{UL} &/or V_{LL} may each be set to 0 V (ground).		0	1	1
7	10 Hz to 100 Hz				1	1	1

RANGE CODING



CONNECTOR LOCATION

PIN ASSIGNMENTS



J1 & J2

Winchester Type MRAC75S-J with type 100-1020S removable pins (facing rear panel)

PROGRAM FORMAT OR PIN ASSIGNMENT / PROG. PARAMETER	MODE SELECT	RANGE 1	RANGE 2	RANGE 4	VERNIER SIGNIFICANT DIGITS MOST 1	MOST 2	MOST 4	MOST 8	MIDDLE 1	MIDDLE 2	MIDDLE 4	MIDDLE 8	LEAST 1	LEAST 2	LEAST 4	LEAST 8
EXT TRIGGER																
REP RATE																
+ TRIG POLARITY																
DELAY																
SYNC GATE																
WIDTH																
ASYNC GATE																
V_{UL}																
PULSE PAIRS																
V_{LL}																
COMPLEMENT																
T_+																
T_-																
OUTPUT OFF																

SPECIAL PIN ASSIGNMENTS: J1-80 and J2-80, chassis ground

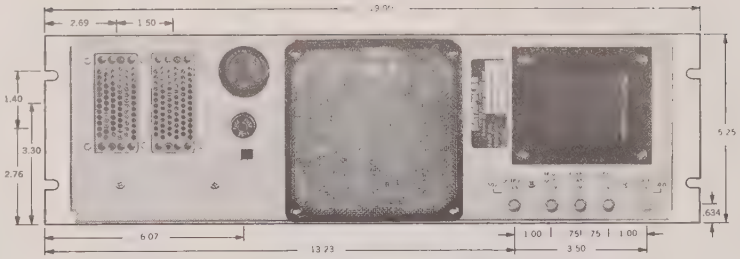
LOGIC LEVELS: +5V true or ground true; customer option

NOTE: T_+ and T_- are variable only on Models 154 and 154-1.

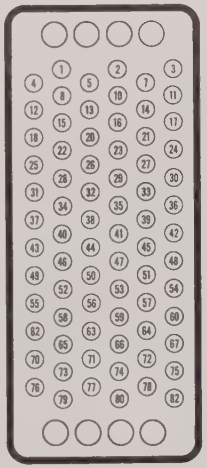
Figure 2-2. Parallel Programming Information

RNG #	REP RATE	DELAY OR WIDTH	V_{UL} OR V_{LL}	T_+ & T_-	BCD 1	BCD 2	BCD 4
0	[illegible]		[illegible]	[illegible]	0	0	0
1	10 MHz to 50 MHz	10 ns to 100 ns	−0.1 V to −1 V	10 ns to 100 ns	1	0	0
2	1 MHz to 10 MHz	0.1 μs to 1 μs	+0.1 V to +1 V	0.1 μs to 1 μs	0	1	0
3	0.1 MHz to 1 MHz	1 μs to 10 μs	+1 V to +10 V	1 μs to 10 μs	1	1	0
4	10 KHz to 100 KHz	10 μs to 100 μs			0	0	1
5	1 KHz to 10 KHz	0.1 ms to 1 ms			1	0	1
6	0.1 KHz to 1 KHz	1 ms to 10 ms	V_{UL} &/or V_{LL} may each be set to 0 V (ground)		0	1	1
7	10 Hz to 100 Hz				1	1	1

RANGE CODING



CONNECTOR LOCATION



J1 & J2

PROGRAM FORMAT		ADDRESS "8"	ADDRESS "4"	ADDRESS "2"	ADDRESS "1"	DATA BITS 1	2	3	4	5	6	7	8
PIN #J1-		25	18	12	4	1	8	15	22	28	34	40	46
REP RATE	A	1	0	0	1	sync gate	range "4"	range "2"	range "1"	800	400	200	100
	B	1	0	1	0	80	40	20	10	8	4	2	1
DELAY	A	1	0	1	1	pulse pairs	range "4"	range "2"	range "1"	800	400	200	100
	B	1	1	0	0	80	40	20	10	8	4	2	1
WIDTH	A	1	1	0	1	async gate	range "4"	range "2"	range "1"	800	400	200	100
	B	1	1	1	0	80	40	20	10	8	4	2	1
V_{UL}	A	0	0	0	1	ext trig	+ trig pol	range "2"	range "1"	800	400	200	100
	B	0	0	1	0	80	40	20	10	8	4	2	1
V_{LL}	A	0	0	1	1	output off	comple ment	range "2"	range "1"	800	400	200	100
	B	0	1	0	0	80	40	20	10	8	4	2	1
T_+	A	0	1	0	1			range "2"	range "1"	800	400	200	100
	B	0	1	1	0	80	40	20	10	8	4	2	1
T_-	A	0	1	1	1					800	400	200	100
	B	1	0	0	0	80	40	20	10	8	4	2	1

SPECIAL PIN ASSIGNMENTS: J1-31, Address Clock; J1-37, Delayed Clock out; J1-80 Chassis Ground.

LOGIC LEVELS: +5V true or ground true; customer option.

NOTE: T_+ and T_- are variable on Models 154.

MODEL 153/154–2 and 3

Figure 2-3. Serial Programming Information

2.11 TRIG POLARITY

Selects the trigger polarity for the external trigger mode. When the pushbutton is depressed triggering with positive pulses is enabled. When the pushbutton is released triggering with negative pulses is enabled.

2.12 DBL PULSE

Selects the double pulse (pulse pairs) mode when the pushbutton is depressed.

2.13 OUTPUT COMPLEMENT

Reverses the time positions of the upper level (V_{UL}) and lower level (V_{LL}) voltages when the pushbutton is depressed. The time position of T_+ and T_- are also reversed.

2.14 OUTPUT OFF

Turns off the output pulse when the pushbutton is depressed (trigger output is uninterrupted).

2.15 OUTPUT Connector

Output connector for the main pulse.

2.16 TRIG OUT Connector

Output connector for the trigger pulse.

2.17 ASYNC GATE Connector

Input connector for an asynchronous gate signal. Impedance is 50 ohms.

2.18 SYNC GATE Connector

Input connector for a synchronous gate signal. Impedance is 50 ohms.

2.19 EXT TRIG Connector

Input connector for an external trigger source. Impedance is 50 ohms.

2.20 J1 and J2 Connectors

Input connectors for the external programming source.

NOTE: Refer to Figure 2-2 for all programming information for parallel instruments. Refer to Figure 2-3 for all programming information for serial instruments.

2.21 AC POWER Connector

Input connector for an ac power source.

2.22 115/230 VOLT SLIDE Switch

Selects the transformer primary configuration for either 115 or 230 volts.

OPERATION

SECTION III

OPERATING INSTRUCTIONS

3.1 GENERAL INSTRUCTIONS

CAUTION

When re-installing D/A cards check carefully to ensure that card is being installed in appropriate connector; all D/A cards have the same polarizing key slots.

The Model 153/154 instruments are fully protected and no combinations of front panel settings, misprogramming, short circuit or external voltage less than 10 volts will cause damage. Refer to Section II for the function of all controls and connectors and for all remote programming information. The ac power connector, fuse and line voltage switch (115/230 V slide switch) are located on the back panel. The proper size fuse is 3.0 amp slow-blow for 115 V and 1.5 amp slow-blow for 230 V operation. Always make sure that the line voltage switch agrees with the power source before connecting the power connector.

3.1.1 Duty Factor Limitation

Duty factor is defined at the ratio of the pulse duration or delay to the duration of the total repetition rate period. Therefore the percentage duty factor is calculated by the following equation:

$$\%\text{duty factor} = \frac{\text{Pulse width or delay}}{\text{rep rate period}} \times 100$$

For example, if the repetition rate is set at 1 MHz and the pulse width or delay is 0.5μs, the duty factor is:

$$\%\text{duty factor} = \frac{0.5 \times 10^6 \times 100}{1 \times 10^6} = 50\%$$

The same duty factor limitations apply for external and internal trigger operation. The limits are 70% for repetition rates below 10 MHz, 50% for repetition rates above 10 MHz.

3.1.2 Double Pulse Minimum Separation

In the double pulse mode, the delay control sets the separation between the two pulses. For proper operation without affecting the pulse shape there are minimum separation limits.

Separation is measured between the trailing edge of the first pulse and the leading edge of the second. Minimum double pulse separation must be greater than 30% of the pulse width or 20 ns, whichever is greater. For example if the width is 0.1μs, the minimum pulse separation should be:

$$\text{minimum separation} = (0.1 \times 10^6) \times (30\%) = 30 \text{ ns}$$

3.1.3 Output Termination

When the instrument is not operating into a 50 ohm load, it must be terminated with 50 ohms at the load under test. A 5 watt termination is recommended, however a 2 watt termination is adequate for most operating conditions. Care should be exercised if a 2 watt termination is used when the instrument is in the complement mode since the maximum power out is 2 watts.

Fifty ohm coaxial cables should be used to connect the instrument to the load. Minimum cable length should be used to prevent deterioration of the pulse quality.

3.2 MANUAL CONTROL OPERATION

When the MAN CONT pushbutton is depressed the output pulse parameters can be controlled by the front panel switches.

3.2.1 External Trigger Mode

With the EXT TRIG switch depressed, an external trigger signal from 10 Hz to 50 MHz with a ±1 V to ±5 V amplitude will generate pulses in the instrument. To operate the instrument in the external trigger mode, proceed as follows:

a. Depress the MAN CONT pushbutton.

b. Depress the EXT TRIG pushbutton and connect the external trigger source to the TRIG IN connector.

c. Select positive or negative trigger polarity by depressing the TRIG POLARITY pushbutton for a positive trigger or releasing it for a negative trigger.

d. Select the DELAY and WIDTH ranges and set the thumbwheels for the desired width and delay. Refer to paragraph 3.1.1 for duty factor limitations.

e. If synchronization is required, connect the TRIG OUT to the external circuit.

f. Select the V_{UL} and V_{LL} ranges and set the thumbwheels for the desired amplitude. The difference between V_{UL} and V_{LL} should not exceed 10 volts. Terminate the OUTPUT with 50 ohms if the load is not 50 ohms.

g. (Model 154 instruments only.) Select the RISE/FALL range and adjust the rise (T_+) and fall (T_-) thumbwheels to the desired setting. Each transition time is independently variable.

h. If a negative-going pulse is desired, depress the OUTPUT COMPLEMENT pushbutton.

i. If the double pulse mode is desired, depress the DBL PULSE pushbutton. Observe the minimum spacing limitation described in paragraph 3.1.2.

3.2.2 Internal Trigger Mode

When the EXT TRIG pushbutton is released the instrument will generate pulses at the rate set by the REP RATE controls. The repetition rate is variable from 10 Hz to 50 MHz. To operate the instrument in the internal trigger mode proceed as follows:

a. Release the EXT TRIG pushbutton.

b. Select the REP RATE range and set the thumbwheels for the desired repetition rate.

c. Perform steps (d) through (i) of paragraph 3.2.1.

3.2.3 Gate Mode

When the SYNC GATE or ASYNC GATE pushbutton is depressed, the output of the instrument will occur for the duration of a +1 V to +5 V pulse applied at the SYNC GATE or ASYNC GATE input. In the SYNC GATE mode the output pulse is synchronized to the gate signal. In the ASYNC GATE mode, the output pulse is not synchronized to the gate signal. To operate the instrument in the SYNC GATE mode proceed as follows:

a. Depress the SYNC GATE pushbutton and connect the gate signal to the SYNC GATE input. Set the amplitude of the gate signal for at least +1 volt (but less than +5 volts). Select the REP RATE range and set the thumbwheels for the desired repetition rate.

b. Set the remaining controls the same as in steps (d) through (i) of paragraph 3.2.1.

c. Connect the OUTPUT connector to the load. The gated output will be synchronized to the gate signal.

d. For asynchronous gating, depress the ASYNC GATE pushbutton and connect the gate signal to the ASYNC GATE input. Set the amplitude of the gate signal for at least +1 volt.

e. Set the instrument controls the same as in steps (d) through (i) of paragraph 3.2.1.

f. Connect the OUTPUT connector to the load. The gated output is synchronized to the gate signal.

3.3 REMOTE PROGRAMMING CONTROL

3.3.1 Parallel Input (Model 153/154–1 and 3)

Parameter range selection is accomplished by a 2 or 3 digit BCD input and vernier control within each range is accomplished by a 12-bit (3 digit; maximum setting 999) BCD inputs. A total of 80 lines are required to fully program the Model 153 and 106 lines are required to fully program the Model 154. A logical one (1) or a true input enables the mode of operation (EXT TRIGGER, +TRIG POLARITY, SYNC GATE, ASYNC GATE, PULSE PAIRS, COMPLEMENT and OUTPUT OFF) or the range or vernier BCD bit. A logical zero (0) or false input disables them. For a positive true instrument all bits that are open circuited will be enabled, therefore if it is desired that a bit be disabled, it must be grounded.

Programming time for all parameters is 100μs with the exception of V_{UL} and V_{LL}, which have a programming time of 3 ms. Parameters may be programmed in any order, however, since programming time for V_{UL} and V_{LL} is longer, it is good practice to program them first. Refer to Figure 2 - 2 for the connector pin assignment for the range and vernier bits and mode selection. Refer to the range coding chart for all parameter range numbers.

3.3.1.1 Sample Program

Figure 3 - 1 shows a sample program. A thorough study and a performance of the program will demonstrate how the instrument is operated. Refer to Figure 2 - 2 for the connector pin assignments for mode selection and range and vernier bits. See range coding charts for range numbers. If the instrument is properly programmed the output should have the characteristics of the pulse displayed in Figure 3 - 2.

3.3.1.2 External Trigger Mode

When the instrument is in the EXTERNAL TRIGGER mode, an external trigger signal from 10 Hz to 50 MHz with a ±1 V to ±5 V amplitude will generate pulse in the instrument. To operate the instrument in the external trigger mode proceed as follows:

a. Connect the programming source to connectors J1 and J2.

b. Connect an external trigger source to TRIG IN connector. Set the trigger source for the desired trigger level (±1 V minimum, ±5 V maximum) and width (10 ns minimum). Program the instrument for EXTERNAL TRIGGER and for positive or negative TRIGGER POLARITY, depending on the polarity of the input signal.

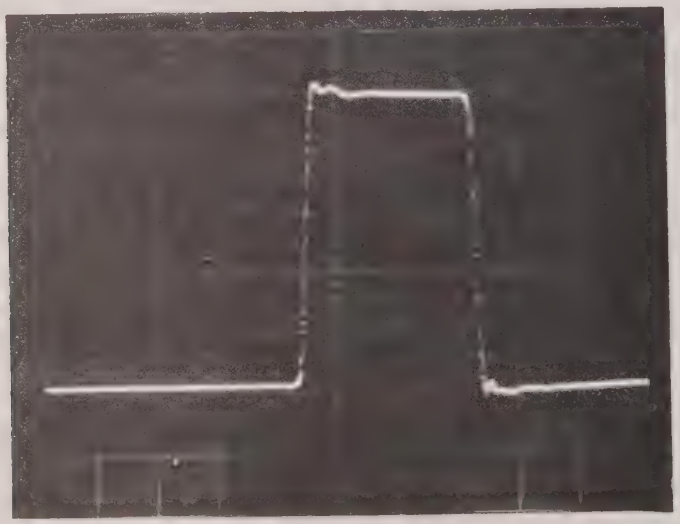
c. Program the remaining pulse parameters as desired. Parameters may be programmed in any order, however it is a good idea to program V_{UL} and V_{LL} first since they require a longer programming time. Observe the maximum duty cycle limitations listed in paragraph 3.1.1.

Figure 3-1. Parallel Input Sample Program

Parameter	Range BCD Setting	Mode Select	Vernier BCD Setting MSD	MD	LSD	
	1 2 4		1 2 4 8	1 2 4 8	1 2 4 8	
REP RATE	1 0 0		0 1 0 0	0 0 0 0	0 0 0 0	(2.00 MHz)
DELAY	1 0 0		1 0 1 0	0 0 0 0	0 0 0 0	(50.0 ns)
WIDTH	1 0 0		1 0 1 0	0 0 0 0	0 0 0 0	(50.0 ns)
V_{UL}	1 1		1 0 0 1	1 0 0 1	1 0 0 1	(+9.99 V)
V_{LL}	1 1		1 0 1 0	0 0 0 0	0 0 0 0	(+5.00 V)
T_+ (Model 154)	0 1 0		1 0 0 1	1 0 0 1	1 0 0 1	(9.99 ns)
T_- (Model 154)	0 1 0		1 0 0 1	1 0 0 1	1 0 0 1	(9.99 ns)
EXT TRIGGER		0				(disabled)
+TRIG POLARITY		0				(disabled)
SYNC GATE		0				(disabled)
ASYNC GATE		0				(disabled)
PULSE PAIRS		0				(disabled)
COMPLEMENT		0				(disabled)
OUTPUT OFF		0				(disabled)

NOTE: A true or a logical one (1) enables the range or vernier bit, or the mode of operation. A false input or a logical zero (0) disables it.

Figure 3-2. Output Waveform Sample Program



Scope Setting: 1 V/cm, 20 ns/cm

CAUTION

The maximum difference between V_{UL} and V_{LL} should not exceed 10 volts and V_{LL} should never be set more positive than V_{UL}.

d. Connect the OUTPUT connector to the load. Terminate the OUTPUT with 50 ohms if the load does not have 50 ohms impedance.

3.3.1.3 Internal Trigger Mode

With the instrument in the INTERNAL TRIGGER mode (external trigger disabled) the instrument will generate pulses at a rate set by the REP RATE controls. To operate the instrument in the INTERNAL TRIGGER mode proceed as follows:

a. Connect the programming source to connectors J1 and J2.

b. Program the instrument for the INTERNAL TRIGGER mode (external trigger mode disabled).

c. Program the instrument for the desired REPETITION RATE. Program the remaining pulse parameters as desired.

d. Connect the OUTPUT connector to the load. Terminate the OUTPUT with 50 ohms if the load does not have 50 ohms impedance.

3.3.1.4 Gate Mode

When the SYNC GATE or ASYNC GATE mode is enabled, the output pulse will occur for the duration of a +1 to +5 V pulse applied at the SYNC GATE or ASYNC GATE input. In the SYNC GATE mode the output pulse is synchronized to the gate signal. In the ASYNC GATE mode the output is not synchronized to the gate signal. To operate the instrument in the SYNC GATE mode proceed as follows:

a. Program the instrument for the SYNC GATE mode and connect the gate signal source to the SYNC GATE input. Set the pulse amplitude of the gate source for at least +1 volt (but less than +5 volts).

b. Program the remaining pulse parameters as desired.

NOTE: The repetition rate period should be set to less than the duration (width) of the gate pulse.

c. Connect the OUTPUT connector to the load. The gated output will be synchronized to the gate signal.

d. For asynchronous gating, program the instrument for the ASYNC GATE mode and connect the gate signal source to the ASYNC GATE input. Set the pulse amplitude of the gate source for at least +1 volt (but less than +5 volts).

e. Connect the OUTPUT connector to the load. The gated output will not be synchronized to the gate signal.

3.3.2 Serial Input (Model 153/154–3)

Programming of Model 153/154–3 is accomplished by 12-bit characters entered serially. Ten 12-bit characters are required to completely program Model 153–3 and 14 are required to completely program Model 154–3. Each major parameter (REP RATE, DELAY, WIDTH, V_{UL}, V_{LL}, T_+ and T_-) require two 12-bit characters for complete programming. The first four bits of each character programs the address information, and the first four data bits of the A character program the range of the major char-

acter and at least one mode of operation (SYNC GATE, EXT TRIGGER, etc.). The remaining four data bits of character A programs the most significant vernier digit and the 8 data bits of character B programs the middle and the least significant vernier digits. To change the state of any one bit in a character, it is necessary to reprogram the entire character (address and data information) in order for the new information to be entered into storage.

Although the 12-bit characters may be programmed into the Series 150 in any order—i.e., any parameter can be arbitrarily programmed before or after any other—it is strongly recommended that, wherever possible, upper and lower voltage levels (V_{UL} & V_{LL}) be programmed first in any programming sequence. This is because they require a programming time of 3 ms as compared to the 100μs maximum required to program all remaining parameters.

Positive-going and negative-going transition times (T_+ & T_-) are each independently settable within the same range. Therefore, when a range is programmed for T_+ it simultaneously programs the range for T_-.

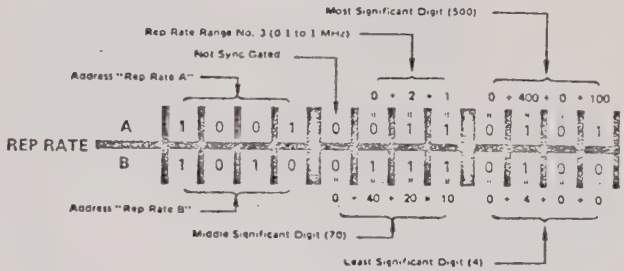
The program information is entered into storage when the trailing edge of the address clock strobe occurs. The delayed clock output occurs approximately 200 ns after the strobe pulse trailing edge. The required clock strobe pulse is positive-going (0 to +5 V) for positive true instruments and negative-going (+5 to 0 V) for ground true instruments. Refer to Figure 2-3 for programming information and connector pin assignments.

3.3.2.1 Sample Program

Figure 3-3 gives two examples of how characters should be programmed. A close study of these two examples will demonstrate how the instrument is operated. Refer to Figure 2-3 for pin assignments. Refer to the range coding chart for range numbers.

EXAMPLE NO. 1

Assume non-gated operation. Set Rep Rate to 574 kHz.


Most Significant Digit (500)
Rep Rate Range No. 3 (0.1 to 1 MHz)
Not Sync Gated
Address "Rep Rate A"
0 • 2 • 1
0 • 400 • 0 • 100
REP RATE
A
B
Address "Rep Rate B"
0 • 40 • 20 • 10
0 • 4 • 0 • 0
Middle Significant Digit (70)
Least Significant Digit (4)

EXAMPLE NO. 2

Set Positive transition Time (T_+) to 169 ns.

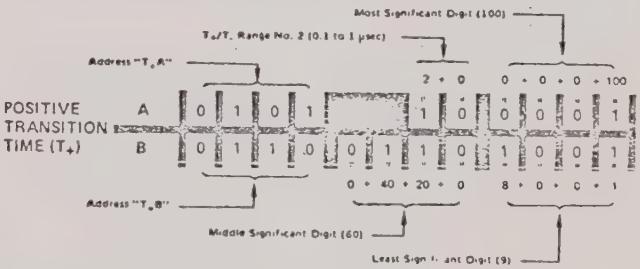


Figure 3-3. Serial Input Sample Program

3.3.2.2 External Trigger Mode

a. To operate the instrument in the EXTERNAL TRIGGER mode perform paragraph 3.3.1.2.

3.3.2.3 Internal Trigger Mode

a. To operate the instrument in the INTERNAL TRIGGER mode perform paragraph 3.3.1.3.

3.3.2.4 Gate Mode

a. To operate the instrument in the SYNC or ASYNC GATE mode perform paragraph 3.3.1.4.

MAINTENANCE

SECTION IV

MAINTENANCE

CAUTION

When re-installing D/A cards check carefully to ensure that card is being installed in appropriate connector; all D/A cards have the same polarising key slots.

4.1 PREVENTIVE MAINTENANCE

Proper care and correct use with regularly scheduled inspections provide the best protection against unnecessary repairs and down time. The Datapulse Series 153/154 Pulse Generators are sensitive laboratory instruments and should not be exposed to severe environmental conditions either in use or in storage. Contaminating or damaging exposure must be avoided at all times if long life and uninterrupted service are expected.

4.1.1 Inspection

Remove the top and bottom covers by removing two flat head Phillips screws on each cover. Inspect for dirt and corrosion and for loose, broken, or burnt parts and wiring. Circuit board discoloration caused by heat may usually be disregarded unless the instrument is inoperative. Inspection intervals should be based on frequency of use and the severity of the environment to which the instrument is exposed.

4.1.2 Cleaning

Accumulated dust and dirt should be removed as often as required. Use either low velocity dry air or a soft nonmetallic brush to clear the interior of foreign matter. Clean dirty parts with a solvent such as trichlorethylene using a soft cloth, and a cotton tipped applicator for narrow spaces.

4.1.3 Recalibration

The instrument is correctly calibrated when it leaves the factory. However, calibration should be checked at regularly scheduled intervals of either accumulated operating hours or calendar time: 500 operating hours or six month intervals is recommended. Refer to paragraph 4.3 for complete calibration instructions.

4.2 PARTS REPLACEMENT

A procedure should be carefully thought out before a part is removed to avoid unnecessary disassembly and accidental damage. Use only direct replacements for parts affecting performance. Transistors temporarily removed should be returned to their original sockets unless defective. Replacement of some parts will necessitate partial recalibration.

4.2.1 Power Transistors

The power transistors for the dc power supplies are mounted on heat sinks. Fiber bushings and mica washers are used to electrically insulate the case (collector) from the heat sink (ground) and a thin film of thermal compound (Wakefield No. 122) is applied to both sides of the mica washers to insure proper thermal conductivity. Incorrectly installed, the transistors may either short out or overheat and fail.

4.2.2 Soldering

Only experienced technicians should replace soldered parts. Printed circuits are vulnerable to excess heat as are many diodes and transistors. The following recommendations should be taken into consideration when replacing soldered parts:

a. Use small diameter rosin core solder and a 35 to 40 watt iron with a wedge

or pointed tip, 1/16 to 1/8 inch wide. The tip must be clean and properly tinned with excess solder removed.

b. Obviously defective parts may be clipped out so their leads can be conveniently unsoldered from the board.

c. Solder only on the circuit side of the board; not on the component side.

d. Apply the tip of the iron directly to the solder joint, at the eyelet, just long enough for the solder to flow.

e. Avoid bringing the iron into contact with the circuit board; overheating will cause the conductor to lift from the board.

f. Use a solder sipper (or some other means) to remove excess solder first when unsoldering a lead, particularly where a lead is bent over, so that it can be straightened before it is pulled out.

g. When a lead is free, clean the hole and remove excess solder, using a solder sipper or a sharp object such as a tooth pick or pointed tool.

h. To prevent heat damage when soldering heat sensitive components, use a heat sink or long nose pliers to grip the lead between the part and the board.

i. Clean the area thoroughly after soldering.

4.3 CALIBRATION

Paragraph 4.3.2 through 4.3.8 provide a complete calibration procedure for the Series 153/154 instruments. Since some adjustments interact with others, follow the procedure in the step sequence given. Refer to Figure 4 - 1 through 4 - 3 for the location of calibration adjustments and test points.

4.3.1 Equipment (or equivalent) Required

a. Digital voltmeter with an accuracy of 0.1%. Systron-Donner Model 7050 recommended.

b. Real-time oscilloscope with a dc to 50 MHz bandwidth. Tektronix Type 546 with a Type 1A2 plug-in recommended.

c. Sampling oscilloscope with a 0.35 ns rise time. Tektronix Type 546 with a Type 1S1 plug-in recommended.

d. A 50 ohm, 5 watt coaxial termination, Datapulse Type 2011 recommended.

e. A 50 ohm, 2 watt coaxial termination. Datapulse Type 2010 recommended.

f. Variable autotransformer with a 2 amp capacity.

g. Electronic counter with a 50 MHz repetition rate capability. Systron-Donner Model 7015 recommended.

h. Two 50 ohm, 2 watt coaxial 10X attenuators. Datapulse Type 2015 recommended.

i. Several 50 ohm coaxial cables terminated with BNC connectors.

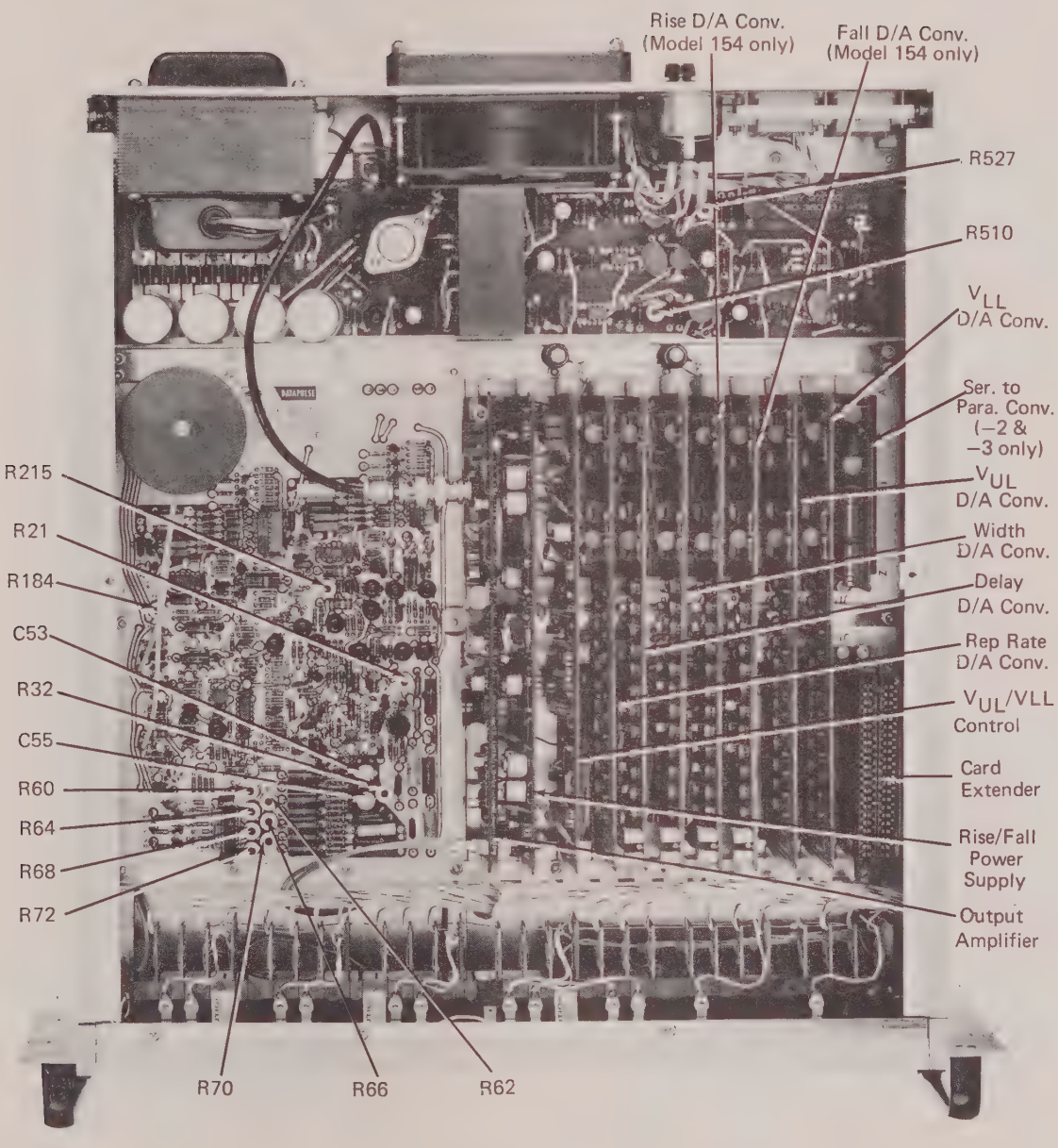


Figure 4-1. Model 153/154 – Top View

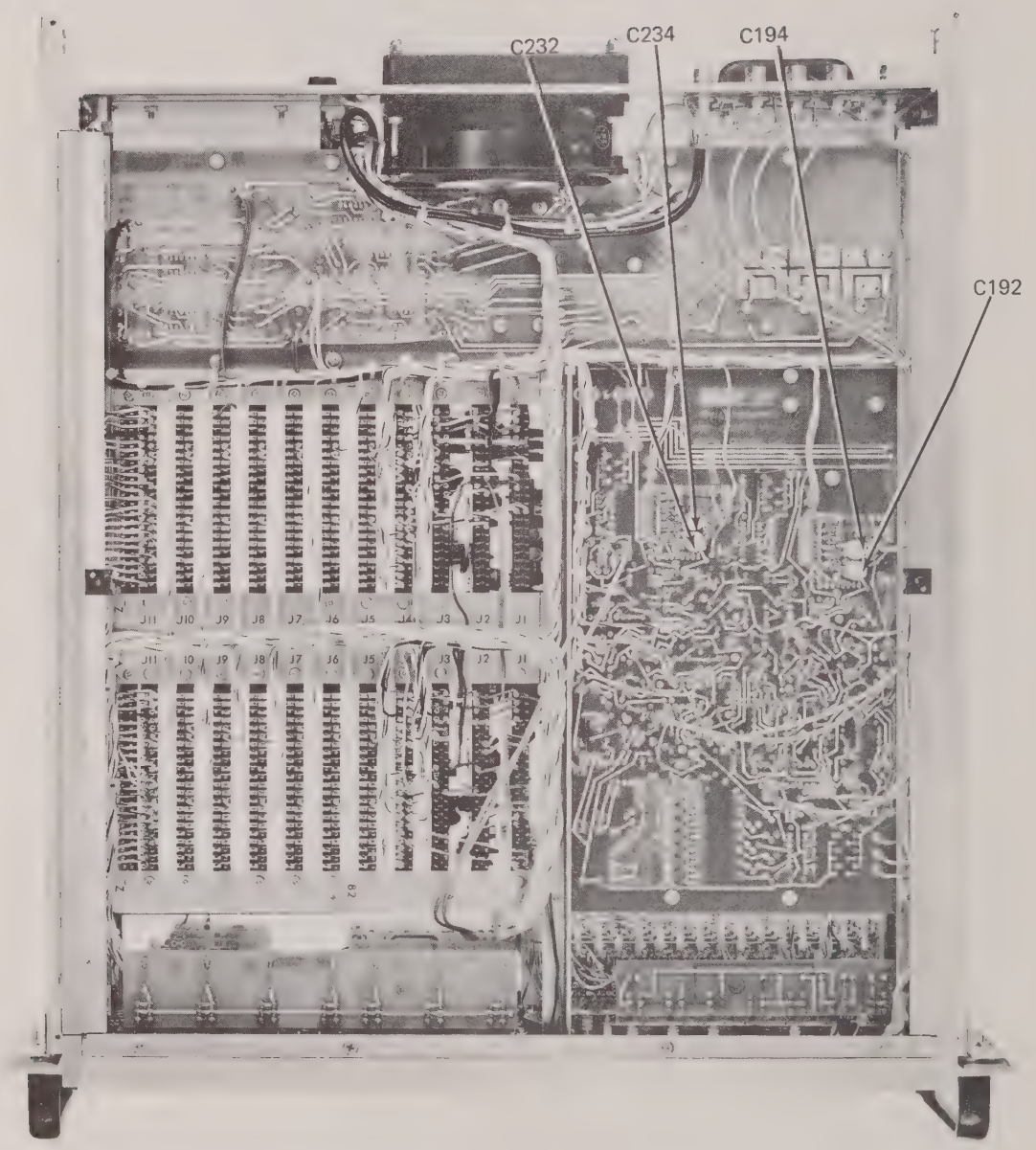


Figure 4-2. Model 153/154 – Bottom View

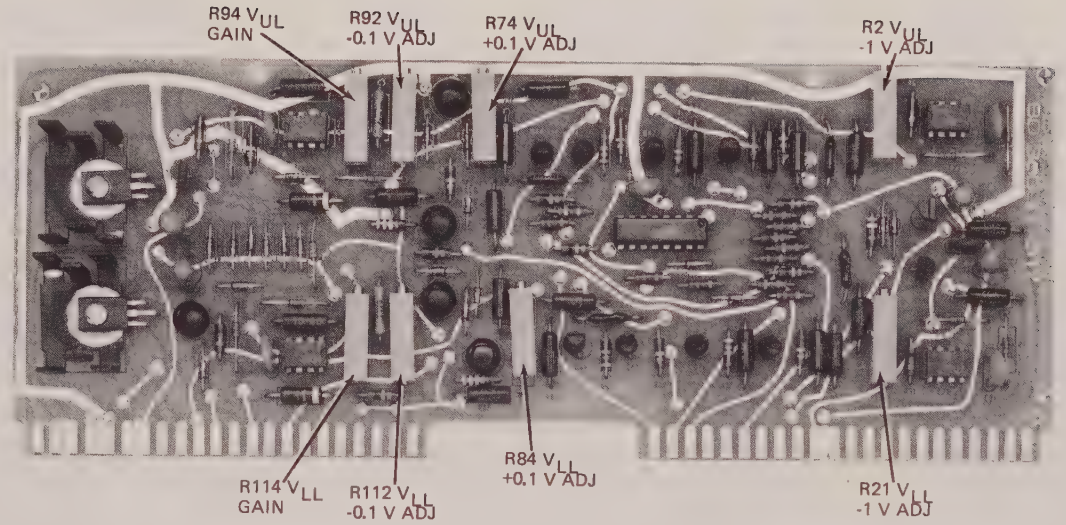


Figure 4-3a. V_{UL}/V_{LL} Control Circuit Adjustments

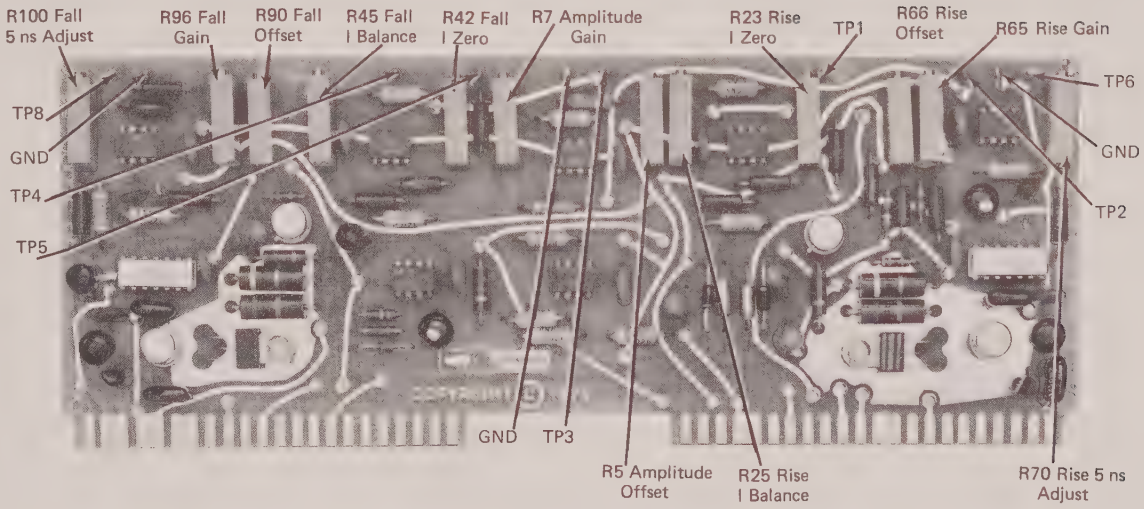


Figure 4-3b. Rise/Fall Power Supply Adjustments

4.3.2 Power Supply Calibration

CAUTION

Verify that the position of the slide switch on the back panel agrees with the line voltage prior to connecting the power plug.

a. Connect the instrument to the autotransformer. Set the autotransformer for 115 volts. Actuate the POWER switch to "on".

b. Connect the digital voltmeter between the +25 volt test point (5B) and ground (5K). Adjust R510 for +25.00 volts dc.

c. Connect the voltmeter between the -25 volt test point (5D) and ground (5K). Adjust R527 for -25.00 volts dc.

d. Connect the voltmeter between the +5 volt test point (5F) and ground (5K). Verify a reading of +5 ±0.1 volts dc.

e. Connect the voltmeter between the -5 volt test point (5J) and ground (5K). Verify a reading of -5 ±0.04 volts dc.

f. Connect the voltmeter between the +2 volt test point (5G) and ground (5K). Verify a reading of +2 ±0.04 volts dc.

4.3.3 Hyperbolic D/A Converters

Refer to Figure 4-1 for the location of the D/A converters. Set all parameter thumbwheels to 000. Install serial to parallel converter card.

4.3.3.1 Delay D/A Converter

a. Set the DELAY thumbwheels to 999 on any range. Adjust R65 fully clockwise. Connect the digital voltmeter across R71 on the delay D/A converter. Adjust R72 for +1.365 V.

b. Retain digital voltmeter setting across R71. Set the DELAY thumbwheels for the following settings and verify the readings on the digital voltmeter are approximately those given.

Setting	Voltmeter Reading
888	1.537 V
777	1.746 V
666	2.035 V
555	2.433 V
444	3.037 V
333	4.038 V
222	5.986 V
111	11.797 V
000	13.60 V

c. Set thumbwheels to 100; increment second digit from one to nine and observe that reading decreases with each step.

d. Repeat procedure in step (c) for least significant (third) digit.

e. After subsequent parts of this procedure are performed, these readings will change. Therefore, a working, calibrated instrument may have different readings from those shown here. If R65 or R72 are adjusted (changed), the entire Delay Calibration procedure must be redone.

4.3.3.2 Width D/A Converter

a. Set the WIDTH thumbwheels to 999 on any range. Adjust R65 fully clockwise. Connect the digital voltmeter across R71. Adjust R72 for 1.365 V ±5 mV.

b. Perform steps (b) through (d) provided in paragraph 4.3.3.1 following adjustment of R72. Repeat step (e), substituting "Width Calibration" for "Delay Calibration".

4.3.4 Repetition Rate Calibration

a. Connect the TRIG OUT connector to the input of the counter. Terminate with the 50 ohm, 5 watt termination at the input to the counter.

b. Set the REP RATE thumbwheels to 100 kHz on the 0.1 to 1 MHz range. Set the remaining parameter thumbwheels to 000. Release all pushbuttons except MAN CONT pushbutton.

c. Adjust R21 for a reading of 100 kHz ±5 kHz.

d. Set the REP RATE thumbwheels for 999 kHz. Adjust R64 for a reading of 1.00 MHz ±50 kHz.

e. Set the REP RATE thumbwheels for 800 kHz. Adjust R32 for 800 kHz ±40 kHz.

f. Starting at 100 kHz, check the entire range at 100 kHz intervals, verifying that all of the readings are within ±5% of the thumbwheel settings. If any readings are out of tolerance, readjust R21, R32 and R64 as required to get all of the readings in tolerance.

g. Set the REP RATE thumbwheels for 1.00 MHz on the 1–10 MHz range. Adjust C55 for 1.00 MHz ±50 kHz.

h. Set the REP RATE thumbwheels for 9.99 MHz. Adjust R62 for 10.0 MHz ±500 kHz.

i. Starting at 1.00 MHz, check the entire range at 1.00 MHz intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

j. Set the REP RATE thumbwheels for 10.0 MHz in the 10–50 MHz range. Adjust C53 for a reading of 10.0 MHz ±500 kHz.

k. Set the REP RATE thumbwheels for 50.0 MHz. Adjust R60 for a reading of 50.0 MHz ±2.5 MHz.

l. Starting at 10.0 MHz, check the entire range at 10.0 MHz intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

m. Set the REP RATE thumbwheels for 99.9 kHz on the 10–100 kHz range. Adjust R66 for a reading of 100 kHz ±5 kHz.

n. Starting at 10.0 kHz, check the entire range at 10.0 kHz intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

o. Set the REP RATE thumbwheels for 9.99 kHz on the 1–10 kHz range. Adjust R68 for a reading of 10.0 kHz ±500 Hz.

p. Starting at 1.00 kHz, check the entire range at 1.00 kHz intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

q. Set the REP RATE thumbwheels for 999 Hz on the 100–1000 Hz range. Adjust R70 for a reading of 1000 Hz ±50 Hz.

r. Starting at 100 Hz, check the entire range at 100 Hz intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

s. Set the REP RATE thumbwheels for 99.9 Hz on the 10–100 Hz range. Adjust R72 for a reading of 100 Hz (10 ms period) ±5 Hz.

t. Starting at 10.0 Hz, check the entire range at 10.0 Hz intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

4.3.5 Delay Range Calibration

a. Connect the OUTPUT connector to the input of the real-time oscilloscope. Terminate with the 50 ohm, 5 watt termination at the oscilloscope. Trigger the oscilloscope from the TRIG OUT connector. Terminate with the 50 ohm, 1 watt termination at the oscilloscope.

b. Set the instrument controls as follows:

Control	Setting
REP RATE	50 kHz (10–100 kHz range)
DELAY	9.99 μs (1–10 μs range)
WIDTH	100 ns (0.1–1 μs range)
RISE (Model 154–1 only)	5 ns (5–10 ns range)
FALL (Model 154–1 only)	5 ns (5–10 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	+1.00 V (+1 V range)
MAN CONT	depressed
DBL PULSE	depressed
Remaining pushbuttons	released

c. Adjust R184 for a delay of 10.0 μs ±0.5μs (measured from the 50% point on the leading edge of the first pulse to the 50% point on the leading edge of the second pulse). Set the DELAY thumbwheels for 1.00μs. Adjust R65 on the Delay D/A Converter for 1.00μs.

d. Starting at 1.00 μs, check the entire range at 1.00μs intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

e. Check the 10–100 μs, 100–1000 μs and 1–10 ms ranges at 10% intervals verifying that all readings are within ±5% of the thumbwheel settings. Change repetition rate as required to prevent exceeding the duty factor limitations. If any readings are out of tolerance, readjust R184 and R65 on the Delay D/A Converter to get all four ranges in tolerance.

f. Disconnect the OUTPUT connector from the real-time oscilloscope. Terminate the output with the 50 ohm, 2 watt, 10X attenuator and connect it to the input of the sampling oscilloscope. Trigger the oscilloscope from the TRIG OUT connector.

g. Set the REP RATE thumbwheels for 500 kHz and WIDTH thumbwheels for 100 ns.

h. Set the DELAY thumbwheels to 999 ns on the 100–1000 ns range. Adjust C194 for a delay of 1000 ns ±50 ns. Reduce the pulse width to 10 ns.

i. Starting with 100 ns, check the entire range at 100 ns intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

j. Set the REP RATE thumbwheels for 5 MHz and the WIDTH thumbwheels for 10 ns.

k. Set the DELAY thumbwheels for 99.9 ns on the 10–100 ns range. Adjust C192 for a delay of 100 ns ±5 ns.

NOTE: To measure delays less than 20 ns, switch to single pulse mode and measure delay from the leading edge of the TRIG OUT pulse.

l. Starting at 10 ns, check the entire range at 10.0 ns intervals verifying that all of the readings are within ±5% +1 ns of the thumbwheel settings.

4.3.6 Width Range Calibration

a. Perform the test set-up the same as in paragraph 4.3.5 step (a).

b. Set the instrument controls the same as in paragraph 4.3.5 step (b), except set the DELAY thumbwheels to 10.0 ns on the 10–1000 ns range, the WIDTH thumbwheels to 9.99μs on the 1–10 μs range and the DBL PULSE pushbutton to the released position.

c. Adjust R215 for a pulse width of 10.0 μs ±0.5 μs (measured from the 50% point on the leading edge to the 50% point on the trailing edge). Set the WIDTH thumbwheels for 1.00μs. Adjust R65 on the width D/A converter for 1.00μs.

d. Starting at 1.00 μs, check the entire range at 1.00μs intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

e. Check the 10–100 μs, 100–1000 μs and 1–10 ms ranges at 10% intervals verifying that all readings are within ±5% of the thumbwheel settings. Change repetition rate as required to prevent exceeding the duty cycle limitations. If any readings are out of tolerance readjust R215 and R65 to get all four ranges in tolerance.

f. Disconnect the OUTPUT connector from the real-time oscilloscope. Terminate the output with a 50 ohm, 2 watt, 10X attenuator and connect it to the input of the sampling oscilloscope. Trigger the oscilloscope from the TRIG OUT connector.

g. Set the REP RATE thumbwheels to 500 kHz. Set the WIDTH thumbwheels for 999 ns on the 100–1000 ns range. Adjust C234 for a pulse width of 1000 ns ±50 ns.

h. Starting at 100 ns, check the entire range at 100 ns intervals verifying that all of the readings are within ±5% of the thumbwheel settings.

i. Set the REP RATE thumbwheels to 5 MHz. Set the WIDTH thumbwheels to 99.9 ns on the 10–100 ns range. Adjust C232 for a pulse width of 100 ns ±5 ns.

j. Starting at 10.0 ns, check the entire range at 10.0 ns intervals verifying that all of the readings are within ±5% +1 ns of the thumbwheel settings.

4.3.7 Rise/Fall Power Supply Calibration (Model 154–1 and 3)

All calibration potentiometers and test points referred to in this paragraph are located on the rise and fall power supply card unless otherwise specified. (Refer to Figure 4-3b).

a. Connect instrument to sampling oscilloscope; terminate with 50 ohm, 2 W coaxial attenuator at oscilloscope.

b. Set the instrument controls as follows:

Control	Setting
REP RATE	100 kHz (100–1000 kHz range)
DELAY	10 ns (10–100 ns range)
WIDTH	3 μs (1–10 μs range)
RISE	1 μs (1–10 μs range)
FALL	1 μs (1–10 μs range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (-10 V range)
MAN CONT	depressed
Remaining pushbuttons	released

c. Set oscilloscope controls to display single pulse on trace.

d. Monitor TP3 with digital voltmeter and adjust AMPLITUDE GAIN to 10.000 volts.

e. Connect digital voltmeter between TP1 and TP2 and ground TP3. Adjust RISE I ZERO for 0.000 volts.

f. Remove ground from TP3 and adjust RISE I BALANCE for minimum change on digital voltmeter reading when rise time is shifted from 1 μs to 9 μs.

g. Set oscilloscope controls to enable display of pulse leading edge, and adjust RISE GAIN for a rise time of 1 μs at +9.99 volts amplitude.

h. Set V_{UL} for +1.99 V amplitude and adjust AMPLITUDE OFFSET for a rise time of 1 μs.

i. Set V_{UL} for +9.99 volts amplitude and monitor TP3 with digital voltmeter; readjust AMPLITUDE GAIN for 10.000 volts.

j. Repeat steps (h) and (i) until both readings remain correct.

k. Set instrument controls as follows:

Control	Setting
REP RATE	10 kHz (10–100 kHz range)
DELAY	10 ns (10–100 ns range)
WIDTH	30 μs (10–100 μs range)
RISE	9 μs (1–10 μs range)
FALL	9 μs (1–10 μs range)
V_{UL}	+1.99 V (+10 V range)
V_{LL}	0.00 V (-10 V range)
RISE OFFSET	Adjust for rise time of 9 μs

l. Set instrument controls as indicated in step (b) and oscilloscope controls as indicated in step (c).

m. Connect digital voltmeter between TP5 and TP4 and ground TP3. Adjust FALL I ZERO for reading of 0.000 volts.

n. Remove ground from TP3 and adjust FALL I BALANCE for minimum change on digital voltmeter when fall time is shifted from 1 μs to 9 μs.

o. Set oscilloscope controls to display trailing edge of pulse; adjust FALL GAIN for fall time of 1 μs at +9.99 volts amplitude.

p. Set instrument controls as indicated in step (k) and adjust oscilloscope controls as required to observe trailing edge of pulse. Adjust FALL OFFSET for a fall time of 9 μs.

q. Set instrument controls as follows:

Control	Setting
REP RATE	1 MHz (1–10 MHz range)
DELAY	10 ns (10–100 ns range)
WIDTH	30 ns (10–100 ns range)
RISE	5 ns (5–10 ns range)
FALL	5 ns (5–10 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (-10 V range)

r. Set oscilloscope controls to display single pulse on trace.

s. Set RISE 5 NS ADJUST for reading of 5 ns rise time. Set FALL 5 NS ADJUST for reading of 5 ns fall time.

4.3.8 V_{UL} and V_{LL} Calibration

All calibration potentiometers and test points referred to in this paragraph are located on the V_{UL}/V_{LL} control card unless otherwise specified. (Refer to Figure 4-3a).

a. Connect the OUTPUT connector to the input of the digital voltmeter. Terminate the output with the 50 ohm, 5 watt termination at the digital voltmeter input.

b. Set instrument controls as follows:

Control	Setting
REP RATE	10.0 Hz (10–100 Hz range)
DELAY	10.0 ns (10–100 ns range)
WIDTH	10.0 ns (10–100 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (-10 V range)
MAN CONT	depressed
OUTPUT COMPLEMENT	depressed
Remaining pushbuttons	released

c. Adjust R94 for an initial setting of +10.00 V dc. In subsequent steps it may be necessary to readjust the value.

d. Set V_{UL} to -0.1 V and V_{LL} to -5.00 V. Adjust R92 for -0.1 V. If R92 cannot be set properly, proceed to step (e).

e. Set V_{UL} to -1.0 V (-10.00 V range), adjust R2 for -1.0 V. Repeat step (d) and verify that voltage adjustment of -1.0 V remains constant.

f. Set V_{UL} for +10.00 V and V_{LL} for 0.00 V. Check entire V_{UL} range at 1 volt intervals and verify that voltage readings are within 5% of thumbwheel settings. If any reading is out of tolerance, readjust R94 (upper end) and R2 (lower end) as necessary.

g. Set V_{UL} for -9.00 V and V_{LL} for -10.00 V. Check entire V_{UL} range at 1 volt intervals and verify that voltage readings are within 5% of thumbwheel settings.

NOTE: Any adjustment of R94 effects the entire V_{UL} range. Therefore, if correct indication cannot be obtained in step (g), repeat adjustment indicated in step (f).

h. Set V_{UL} to +0.1 V (+1.00 V range) and V_{LL} to -5.00 V (-10.00 V range). Adjust R74 for +0.1 V.

i. Verify that +1.0 V and -1.0 V V_{UL} ranges are within 5% (or 50 mV) of the thumbwheel settings over entire range at 100 mV intervals.

j. Release the OUTPUT COMPLEMENT pushbutton.

k. Set the V_{LL} thumbwheels to +9.00 V and V_{UL} to +10.00 V. Adjust R114 for +9.99 V dc.

l. Set V_{LL} to -0.1 V and V_{UL} to +5.00 V. Adjust R112 for -0.1 V.

m. Set V_{LL} to -1.00 V (-10.00 V range). Adjust R21 for -1.00 V. Repeat step (l); verify that voltage adjustment of -1.00 V remains constant.

n. Set V_{LL} for +9.00 V and V_{UL} to +10.00 V. Check entire V_{LL} range at 1 volt intervals and verify that the voltage readings are within 5% of thumbwheel settings. If any reading is out of tolerance, readjust R114 (upper end) and R21 (lower end).

o. Set V_{UL} to 0.00 V and V_{LL} to -10.00 V. Check entire V_{LL} range at 1 volt intervals and verify that voltage readings are within 5% of thumbwheel settings.

NOTE: Any adjustment of R114 effects the entire V_{LL} range. Therefore, if correct indications cannot be obtained in step (o), repeat adjustment indicated in step (n).

p. Set V_{LL} to +0.1 V and V_{UL} to +5.00 V. Adjust R84 for +0.1 V.

q. Verify that +1 V and -1 V V_{LL} ranges are within 5% (or 50 mV) of the thumbwheel settings over entire range at 100 mV intervals.

r. Verify that all rise/fall readings are within tolerance ±(5% +1 ns) of thumbwheel settings, 10% at less than 2 volts amplitude. If any reading is out of tolerance, repeat steps (g) through (k) for rise time and steps (m) through (q) for fall time of previous paragraph 4.3.7.

NOTE: If the 1–10 μs range cannot be adjusted to specifications or the 10–100 ns or 0.1–1 μs range is out of tolerance, the value of the timing capacitor in the output amplifier (37000 - 954) can be varied slightly. Capacitor C4 is for the 10–100 ns range, C7 is for the 0.1–1 μs range and C10 is for the 1–10 μs range. The 5–10 ns range has no timing capacitor.

4.4 SPECIFICATION VERIFICATION

This section is designed to assist in comparing the Model 153/154 with the published specifications. These checks may be used for incoming inspection and after repair checks. If the instrument does not meet the requirement outlined in this section, refer to the calibration procedure (paragraph 4.3).

4.4.1 Equipment (or equivalent) Required

The same equipment listed in paragraph 4.3.1 can be used in these checks.

4.4.2 Repetition Rate Check

a. Monitor the OUTPUT connector with the counter. Terminate the OUTPUT with the 50 ohm, 5 watt termination.

b. Set the instrument controls as follows:

Control	Setting
REP RATE	10 Hz (10–100 Hz range)
WIDTH	10 ns (10–100 ns range)
DELAY	10 ns (10–100 ns range)
RISE/FALL (Model 154 only)	5 ns (5–10 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)
MAN CONT	depressed
Remaining pushbuttons	released

c. Perform Table 4-1 for the repetition rate ranges. Verify that all readings are within ±5% of the thumbwheel settings.

4.4.3 Delay Check

a. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the TRIG OUT connector.

b. Set the instrument controls the same as in paragraph 4.4.2 step (b) except set the DELAY for 1.00 ms on the 1–10 ms range and depress the DBL PULSE pushbutton.

c. Perform Table 4 - 2 for the delay ranges. Verify that all readings are within ±5% of the thumbwheel settings. Change the repetition rate as required to remain within the duty cycle limitations. Delays less than 20 ns must be measured from the TRIG OUT pulse. Use the sampling oscilloscope to check the 0.1–1 μs and the 10–100 ns ranges. Attenuate the output as required when using the sampling oscilloscope.

4.4.4 Width Checks

a. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the TRIG OUT connector.

b. Set the instrument controls the same as in paragraph 4.4.2 step (b) except set the WIDTH for 1.00 ms on the 1–10 ms range. Set the oscilloscope controls to display a single pulse on the trace.

c. Perform Table 4 - 2 for the width ranges. Verify that all readings are

Table 4-1. Repetition Rate Checks

Thumbwheel Setting	Counter Indication						
	10–100 Hz Range	100–1000 Hz Range	1–10 kHz Range	10–100 kHz Range	0.1–1 MHz Range	1–10 MHz Range	10–50 MHz Range
100	95 to 105 ms	95 to 105 Hz	950 to 1050 Hz	9.5 to 10.5 kHz	95.0 to 105 kHz	0.95 to 1.05 MHz	9.5 to 10.5 MHz
200	47.5 to 52.5 ms	190 to 210 Hz	1.9 to 2.1 kHz	19.0 to 21.0 kHz	190 to 210 kHz	1.9 to 2.1 MHz	19.0 to 21.0 MHz
300	31.3 to 34.7 ms	285 to 315 Hz	2.85 to 3.15 kHz	28.5 to 31.5 kHz	285 to 315 kHz	2.85 to 3.15 MHz	28.5 to 31.5 MHz
400	23.7 to 26.3 ms	380 to 420 Hz	3.8 to 4.2 kHz	38.0 to 42.0 kHz	380 to 420 kHz	3.8 to 4.2 MHz	38.0 to 42.0 MHz
500	19 to 21 ms	475 to 525 Hz	4.75 to 5.25 kHz	47.5 to 52.5 kHz	475 to 525 kHz	4.75 to 5.25 MHz	47.5 to 52.5 MHz
600	15.8 to 17.4 ms	570 to 630 Hz	5.7 to 6.3 kHz	57.0 to 63.0 kHz	570 to 630 kHz	5.7 to 6.3 MHz	
700	13.5 to 14.9 ms	665 to 735 Hz	6.65 to 7.35 kHz	66.5 to 73.5 kHz	665 to 735 kHz	6.65 to 7.35 MHz	
800	11.9 to 13.1 ms	760 to 840 Hz	7.6 to 8.4 kHz	76.0 to 84.0 kHz	760 to 840 kHz	7.6 to 8.4 MHz	
900	10.6 to 11.7 ms	855 to 945 Hz	8.55 to 9.45 kHz	85.5 to 94.5 kHz	855 to 945 kHz	8.55 to 9.45 MHz	
999	09.5 to 10.5 ms	950 to 1050 Hz	9.5 to 10.5 kHz	95.0 to 105 kHz	0.95 to 1.05 MHz	9.5 to 10.5 MHz	

Table 4-2. Delay/Width Checks

Thumbwheel Setting	Oscilloscope Indication*					
	1–10 ms Range	0.1–1 ms Range	10–100 μs Range	1–10 μs Range	0.1–1 μs Range	10–100 ms Range
100	0.95 to 1.05 ms	95.0 to 105 μs	9.5 to 10.5 μs	0.95 to 1.05 μs	95.0 to 105 ns	9.5 to 10.5 ns
200	1.9 to 2.1 ms	190 to 210 μs	19.0 to 21.0 μs	1.9 to 2.1 μs	190 to 210 ns	19.0 to 21.0 ns
300	2.85 to 3.15 ms	285 to 315 μs	28.5 to 31.5 μs	2.85 to 3.15 μs	285 to 315 ns	28.5 to 31.5 ns
400	3.8 to 4.2 ms	380 to 420 μs	38.0 to 42.0 μs	3.8 to 4.2 μs	380 to 420 ns	38.0 to 42.0 ns
500	4.75 to 5.25 ms	475 to 525 μs	47.5 to 52.5 μs	4.75 to 5.25 μs	475 to 525 ns	47.5 to 52.5 ns
600	5.7 to 6.3 ms	570 to 630 μs	57.0 to 63.0 μs	5.7 to 6.3 μs	570 to 630 ns	57.0 to 63.0 ns
700	6.65 to 7.35 ms	665 to 735 μs	66.5 to 73.5 μs	6.65 to 7.35 μs	665 to 735 ns	66.5 to 73.5 ns
800	7.6 to 8.4 ms	760 to 840 μs	76.0 to 84.0 μs	7.6 to 8.4 μs	760 to 840 ns	76.0 to 84.0 ns
900	8.55 to 9.45 ms	855 to 945 μs	85.5 to 94.5 μs	8.55 to 9.45 μs	855 to 945 ns	85.5 to 94.5 ns
999	9.5 to 10.5 ms	0.95 to 1.05 ms	95.0 to 105 μs	9.5 to 10.5 μs	0.95 to 1.05 μs	95.0 to 105 ns

*ALL READINGS ±1 NS

within ±5% of the BCD (thumbwheel) settings. Change the repetition rate as required to remain within the duty cycle limitations. Use the sampling oscilloscope to check the 0.1–1 μs and the 10–100 ns ranges. Attenuate the output as required when using the sampling oscilloscope.

4.4.5 V_{UL}/V_{LL} Checks

a. Monitor the OUTPUT with the digital voltmeter. Terminate the OUTPUT with the 50 ohm, 5 watt termination.

b. Set the instrument controls the same as in paragraph 4.4.2 step (b) except depress the COMPLEMENT pushbutton and the external trigger pushbutton.

c. Perform Table 4 - 3 for the +10 V V_{UL} range then set V_{LL} for -10 V and perform Table 4 - 3 for -10 V V_{LL} range.

d. Release the COMPLEMENT pushbutton and set both V_{UL} and V_{LL} for +10 V. Perform Table 4 - 3 for the +10 V V_{LL} range then set V_{UL} for 0 V and perform Table 4 - 3 for the -10 V V_{LL} range.

CAUTION

When performing Table 4 - 3 the maximum difference between V_{UL} and V_{LL} should not exceed 10 volts and V_{LL} should never be set more positive than V_{UL}. For example, when checking the +10 volt V_{UL} range set V_{LL} at 0 volts and when checking the -10 volt V_{UL} range, set V_{LL} at -10 volts.

4.4.6 Transition Time Checks

4.4.6.1 Fixed Transition Times (Model 153 only)

a. Monitor the OUTPUT with the sampling oscilloscope (attenuate as required). Trigger the oscilloscope from the TRIG OUT connector.

b. Set the instrument controls the same as in paragraph 4.4.2 step (b), except set the REPETITION RATE for 10 MHz and the WIDTH to 50 ns. Set the oscilloscope controls to display a single pulse on the trace.

c. Verify that the rise (T_+) and fall (T_-) times are < 5 ns.

4.4.6.2 Variable Transition Times (Model 154 only)

a. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input.

b. Set the instrument controls as follows:

Control	Setting
REP RATE	100 Hz (100–1000 Hz range)
WIDTH	5.00 ms (1–10 ms range)
DELAY	10.0 ns (10–100 ns range)
RISE/FALL	1.00 μs (10–100 μs range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)
MAN CONT	depressed
Remaining pushbuttons	released

Table 4-3. V_{UL}/V_{LL} Range Checks

Thumbwheel Setting	Voltmeter Indication			
	+10 Volt V_{UL} Range	-10 Volt V_{UL} Range	+10 Volt V_{LL} Range	-10 Volt V_{LL} Range
100	0.95 to 1.05 V	-0.95 to -1.05 V	0.95 to 1.05 V	-0.95 to -1.05 V
200	1.9 to 2.1 V	-1.9 to -2.1 V	1.9 to 2.1 V	-1.9 to -2.1 V
300	2.85 to 3.15 V	-2.85 to -3.15 V	2.85 to 3.15 V	-2.85 to -3.5 V
400	3.8 to 4.2 V	-3.8 to -4.2 V	3.8 to 4.2 V	-3.8 to -4.2 V
500	4.75 to 5.25 V	-4.75 to -5.25 V	4.75 to 5.25 V	-4.75 to -5.25 V
600	5.7 to 6.3 V	-5.7 to -6.3 V	5.7 to 6.3 V	-5.7 to -6.3 V
700	6.65 to 7.35 V	-6.65 to -7.35 V	6.65 to 7.35 V	-6.65 to -7.35 V
800	7.6 to 8.5 V	-7.6 to -8.5 V	7.6 to 8.5 V	-7.6 to -8.5 V
900	8.55 to 9.45 V	-8.55 to -9.45 V	8.55 to 9.45 V	-8.55 to -9.45 V
999	9.5 to 10.5 V	-9.5 to -10.5 V	9.5 to 10.5 V	-9.5 to -10.5 V

c Perform Table 4-4 for the rise (T_+) and fall (T_-) times. Change the repetition rate and width as required to make the readings. Use the sampling oscilloscope to check the 10–100 ns and 5–10 ns ranges. Attenuate the output as required when using the sampling oscilloscope.

d. Compute the rise and fall time linearity by the following equation:

$$\%L - \frac{X}{t} 0.100$$

where x = deviation in time from the reference line
and t = time between the 10% and 90% points (see Figure 4-4).

NOTE: The reference line is selected so that maximum + and – deviations are minimized.

e. Verify that the linearity is ±5% for rise and fall times above 10 ns and 10% for rise and fall times below 10 ns.

4.4.7 Waveform Aberrations Check

a. Monitor the OUTPUT with the sampling oscilloscope (attenuate as required). Trigger the oscilloscope from the TRIG OUT connector.

b. Set the instrument controls as follows:

Control	Setting
REP RATE	10 MHz (10–50 MHz range)
WIDTH	50 ns (10–100 ns range)
DELAY	10 ns (10–100 ns range)
RISE/FALL (Model 154 only)	5 ns (5–10 ns range)
V_{UL} controls	9.99 V (+10 V range)
V_{LL} controls	0.00 V (+1 V range)

c. Set the oscilloscope to display a single pulse on the trace. Verify that the aberrations (overshoot, preshoot and ringing) are less than 5% of the ampli-

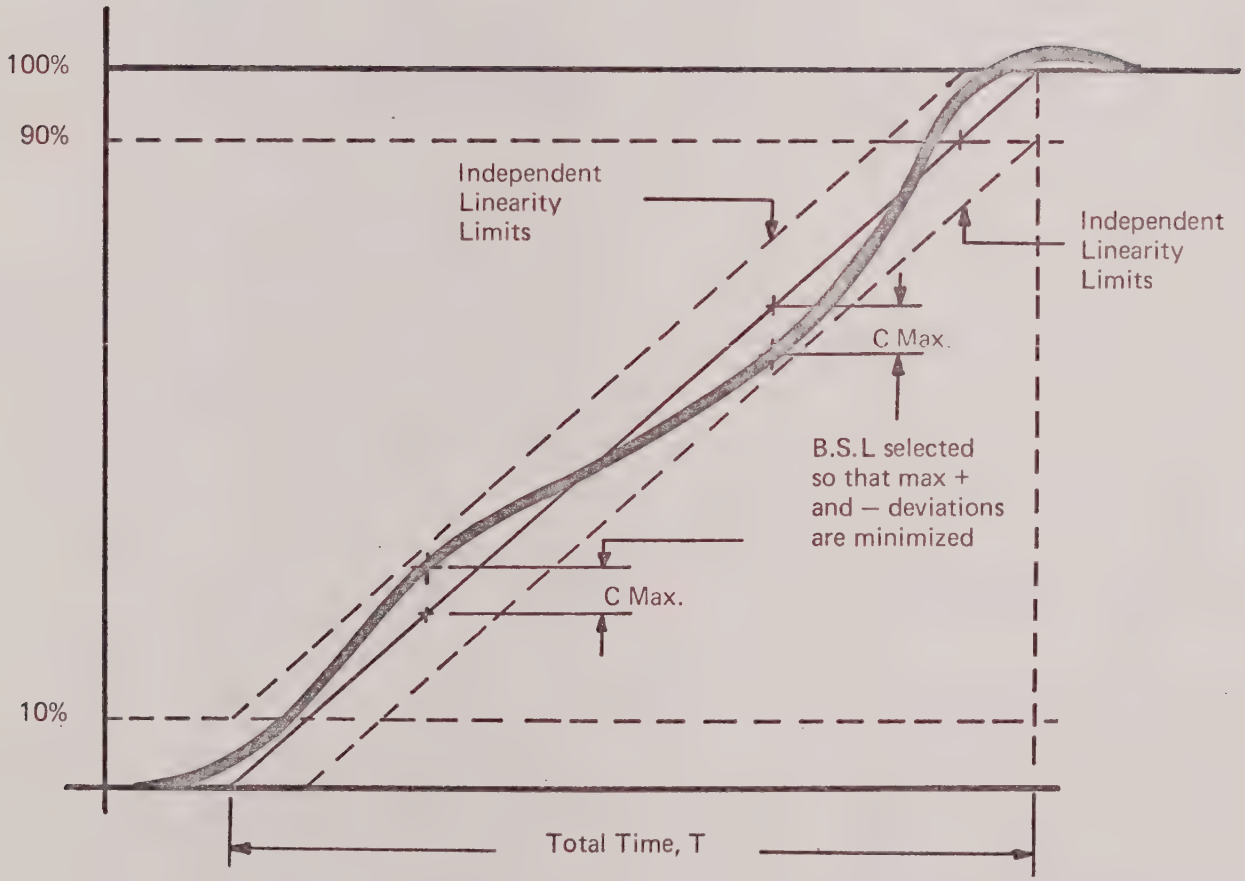


Figure 4-4. Linearity Characteristics

Table 4-4. Rise (T_+)/Fall (T_-) Time Checks

Thumbwheel Setting	Oscilloscope Indication*			
	1–10 μs Rise/Fall Range	100–1000 ns Rise/Fall Range	10–100 ns Rise/Fall Range	5–10 ns Rise/Fall Range
100	0.95 to 1.05 μs	95 to 105 ns	9.5 to 10.5 ns	
200	1.9 to 2.1 μs	190 to 210 ns	19.0 to 21.0 ns	
300	2.85 to 3.15 μs	285 to 315 ns	28.5 to 31.5 ns	
400	3.8 to 4.2 μs	380 to 420 ns	38.0 to 42.0 ns	
500	4.75 to 5.25 μs	475 to 525 ns	47.5 to 52.5 ns	5 ns ±5% +1 ns
600	5.7 to 6.3 μs	570 to 630 ns	57.0 to 63.0 ns	5.7 to 6.3 ns
700	6.65 to 7.35 μs	665 to 735 ns	66.5 to 73.5 ns	6.65 to 7.35 ns
800	7.6 to 8.4 μs	760 to 840 ns	76.0 to 84.0 ns	7.6 to 8.4 ns
900	8.55 to 9.45 μs	855 to 945 ns	85.5 to 94.5 ns	8.55 to 9.45 ns
999	9.5 to 10.5 μs	0.95 to 1.05 μs	95.0 to 105 ns	9.5 to 10.5 ns

*ALL READINGS ±1 NS

tude (see Figure 4-5 for pulse characteristics).

d. Set V_{UL} for +1.00 volt and verify that the aberrations are less than 5% of the amplitude.

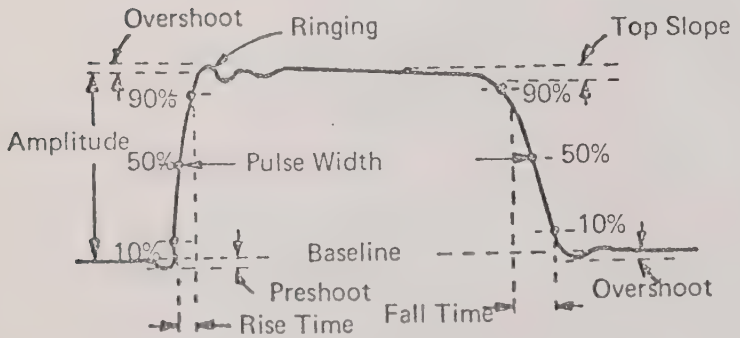


Figure 4-5. Pulse Characteristics

4.4.8 Jitter Check (Repetition Rate, Delay and Width)

a. Set the instrument controls as follows:

Control	Setting
REP RATE	100 Hz (100–1000 Hz range)
DELAY	10.0 ns (10–100 ns range)
WIDTH	1.00 ms (1–10 ms range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)
RISE/FALL (Model 154–1 and 3)	5 ns (5–10 ns range)
MAN CONT	depressed
Remaining pushbuttons	released

b. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope. Trigger the oscilloscope from the TRIG OUT connector. Terminate with the 50 ohm, 2 watt termination at the oscilloscope.

c. Set the oscilloscope controls to display several pulses on the trace. Select any two pulses and compute the percentage of jitter by the following equation:

$$\%\text{Jitter} = \frac{(J2-J1)}{T}\ 100$$

where J1 = leading edge jitter of the first pulse
where J2 = leading edge jitter of the second pulse
where T = time period between the leading edge of the first pulse and the leading edge of the second pulse (see Figure 4-6a).

d. Verify that the repetition rate jitter is < 0.05% of 200 ps (whichever is greater). Check the repetition rate jitter at several points up to 1 MHz and verify that the jitter is < 0.05% or 200 ps (whichever is greater). Decrease the pulse width as required. Check the repetition rate jitter above 1 MHz on the sampling oscilloscope. Attenuate the output as required when using the sampling oscilloscope.

e. Set the instrument the same as in step (a) except set the DELAY thumbwheels for 5.00 ms on the 1–10 ms range.

f. Monitor the OUTPUT and the TRIG OUT on the dual-trace real-time oscilloscope. Trigger the oscilloscope with the leading edge of the TRIG OUT pulse. Set the oscilloscope controls to display one pulse on each trace.

g. Compute the delay jitter by the following equation:

$$\%\text{Jitter} = \frac{(J2-J1)}{T}\ 100$$

where J1 = jitter on the leading edge of the TRIG OUT pulse
where J2 = jitter on the leading edge of the OUTPUT pulse
where T = the time period (delay) between the leading edge of the TRIG OUT pulse and the leading edge of the OUTPUT pulse (see Figure 4 - 6b).

h. Verify that the delay jitter is <0.05% or 200 ps (whichever is greater). Check the jitter at several delay periods and verify that the jitter is<0.05% or 200 ps (whichever is greater). Change the repetition rate as required to remain within the duty factor limitations listed in paragraph 3.1.1. Use the sampling oscilloscope to check the jitter for delay periods below 10μs.

i. Set the instrument the same as in step (a) except set the width for 5.00 ms on the 1–10 ms range.

j. Monitor the OUTPUT on the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination. Trigger the oscilloscope internally on the leading edge of the pulse. Set the oscilloscope control to display a single pulse on the trace.

k. Compute the width jitter by the following equation:

$$\%\text{Jitter} = \frac{(J2-J1)}{T}\ 100$$

where J1 = jitter of the pulse leading edge
where J2 = jitter of the pulse trailing edge
where T = pulse width (see Figure 4-6c).

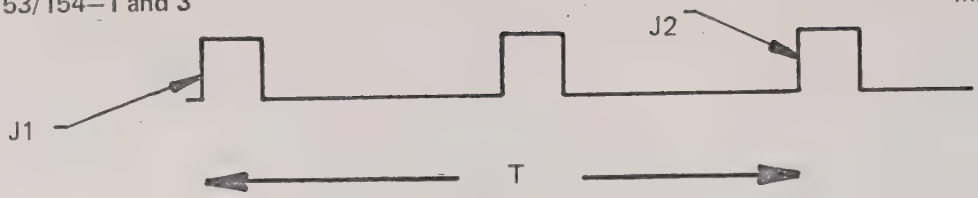


Figure 4-6a. Rep Rate Jitter

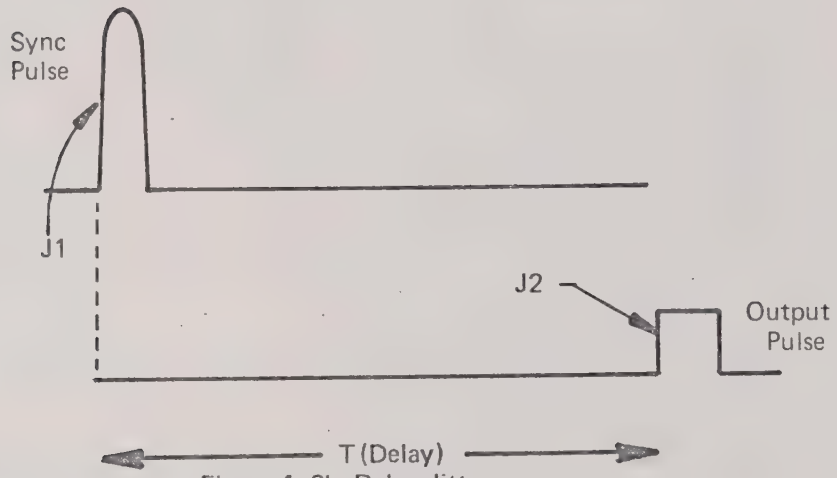


Figure 4-6b. Delay Jitter

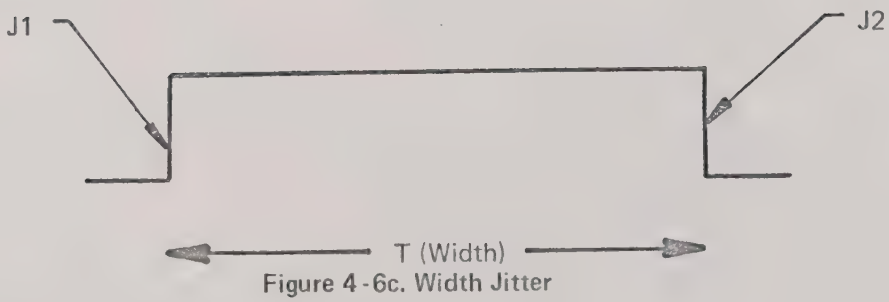


Figure 4-6c. Width Jitter

l. Verify that the width jitter if<0.05% or 200 ps (whichever is greater). Check the jitter at several pulse widths and verify that the jitter is < 0.05%. Change the repetition rate as required to remain within the duty factor limitations listed in paragraph 3.1.1. Use the sampling oscilloscope to check the jitter for pulse width below 10μs.

4.4.9 External Trigger Check

a. Connect the external trigger source to the TRIG IN connector. Set the trigger source for a repetition rate of 10 Hz, a width of 10 ns and an amplitude of +1 volt.

b. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the TRIG OUT connector.

c. Set the instrument controls as follows:

Control	Setting
WIDTH	10 ns (10–100 ns range)
DELAY	10 ns (10–100 ns range)
RISE/FALL (Model 154 only)	5 ns (5–10 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)

d. Depress the EXT TRIG AND TRIG POLARITY pushbuttons and verify that the instrument is triggered. Verify that the instrument can be triggered up to 50 MHz.

e. Set the external trigger source for a -1 volt pulse and release the TRIG POLARITY pushbutton. Verify that the instrument can be triggered from 10 Hz to 50 MHz.

4.4.10 Gate Mode Check

a. Connect the external gate source to the SYNC GATE connector. Set the gate source for a repetition rate of 50 kHz, a width of 100μs and a +1 volt amplitude.

b. Set the instrument controls as follows:

Control	Setting
REP RATE	1.00 MHz (1–10 MHz range)
DELAY	10.0 ns (10–100 ns range)
WIDTH	10.0 ns (10–100 ns range)
V_{UL}	+9.99 V (+10 V range)
V_{LL}	0.00 V (+1 V range)

c. Monitor the OUTPUT with the real-time oscilloscope. Terminate the OUTPUT with the 50 ohm, 5 watt termination at the oscilloscope input. Trigger the oscilloscope from the sync output of the gate source.

d. Depress the SYNC GATE pushbutton and verify that the output is gated (output occurs in groups of pulses at a 50 kHz rate and a duration of 100μs). Release the SYNC GATE pushbutton.

e. Disconnect the gate source from the SYNC GATE connector and connect it to the ASYNC GATE connector. Depress the SYNC GATE pushbutton and verify that the output is gated.

NOTE: The output will be unstable since the oscilloscope is being triggered from the gate source.

SECTION V

THEORY OF OPERATION

5.1 GENERAL DESCRIPTION

Refer to Block Diagram 41000 - 230 for the following explanation.

Time reference for the instrument is provided either by the rep rate multivibrator or an external trigger source. In the external trigger mode, the rep rate multivibrator is disabled. Pulses from the rep rate multivibrator, or the external trigger source, are standardized and shaped by a Schmitt trigger, then differentiated to drive the delay one-shot and the single/double pulse circuit. The differentiated pulses are also amplified and provided at the back panel as the trigger output.

The delay one-shot, a monostable multivibrator is shifted to its unstable state by each incoming trigger pulse. The output of the delay one-shot is delayed from the input by an amount determined by the front panel control or an external programming source. In the single pulse mode, the output of the delay one-shot drives the width one-shot. In the double pulse mode, the delayed pulse from the delay one-shot and the pulse from the trigger shaper drive the width one-shot. The resulting width one-shot output is two essentially identical pulses per repetition rate period, separated by the amount of set or programmed delay.

The width one-shot supplies two pulses of opposite polarity (for each input pulse) to the normal/complement circuit whose output supplies two pulses of opposite polarity to the rise and fall circuit. These two opposite polarity pulses switch a fixed current source (Model 153—1 and 3) or positive and negative variable current sources (Model 154—1 and 3) to charge the rise and fall capacitor in the rise and fall output circuit. The amplitude of the output pulse is determined by the upper level (V_{UL}) and lower level (V_{LL}) voltages supplied by the V_{UL}/V_{LL} control to the rise and fall clamp diodes (CR433 and CR438). Power amplification of the pulse also takes place in the rise and fall output circuit.

When the complement mode is selected, the polarities of the pulses from the normal/complement circuit are reversed, resulting in the time position of the upper and lower levels of the output pulse being reversed. The transition times (T_+ and T_-) are reversed also in instruments with variable rise (T_+) and fall (T_-) times (Model 154—1 and 3).

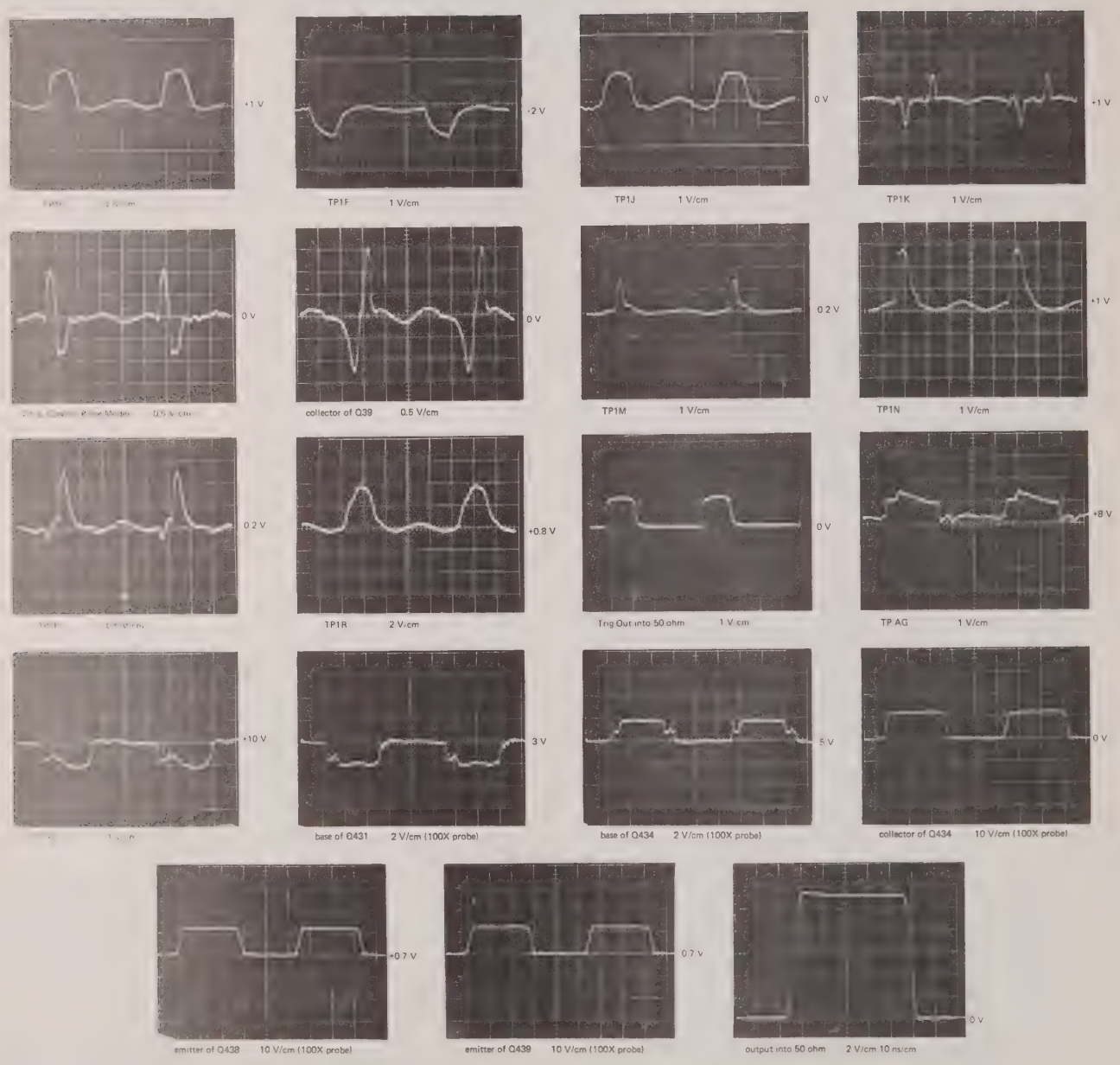
Selecting the synchronous gate mode disables the rep rate multivibrator. When the sync gate signal is applied, the rep rate multivibrator is enabled and continues to operate for the time interval of the gate signal and thus allows the output to occur for the same time interval. Synchronous gating results in an output that is synchronized with the gate signal. For asynchronous gating, the rep rate multivibrator is operative, however, the trigger pulses to the delay one-shot are blocked. The async gate signal enables the input to the delay one-shot for its duration and thus allows the output to occur for the same time interval. Asynchronous gating results in an output that is not synchronized with the gate signal.

5.2 DETAILED CIRCUIT DESCRIPTION

For paragraph 5.2.1 through 5.2.11 refer to Schematic 40000 - 421 and the applicable simplified schematic. Refer to Figure 5 - 1 for waveform photographs.

5.2.1 Repetition Rate Multivibrator

Figure 5 - 2 is a simplified schematic of the repetition rate multivibrator. Transistors Q10 and Q12 comprise the basic multivibrator. Range timing capaci-



Waveform photographs were taken with the following instrument setting
Rep Rate 10 MHz, Delay minimum, Width 50 ns, V_{UL} +10 V, V_{LL} 0 V
Oscilloscope used: Sampling oscilloscope with 10X probe unless otherwise specified. Horizontal setting 20 ns/cm unless otherwise specified

Figure 5-1. Waveform Diagrams

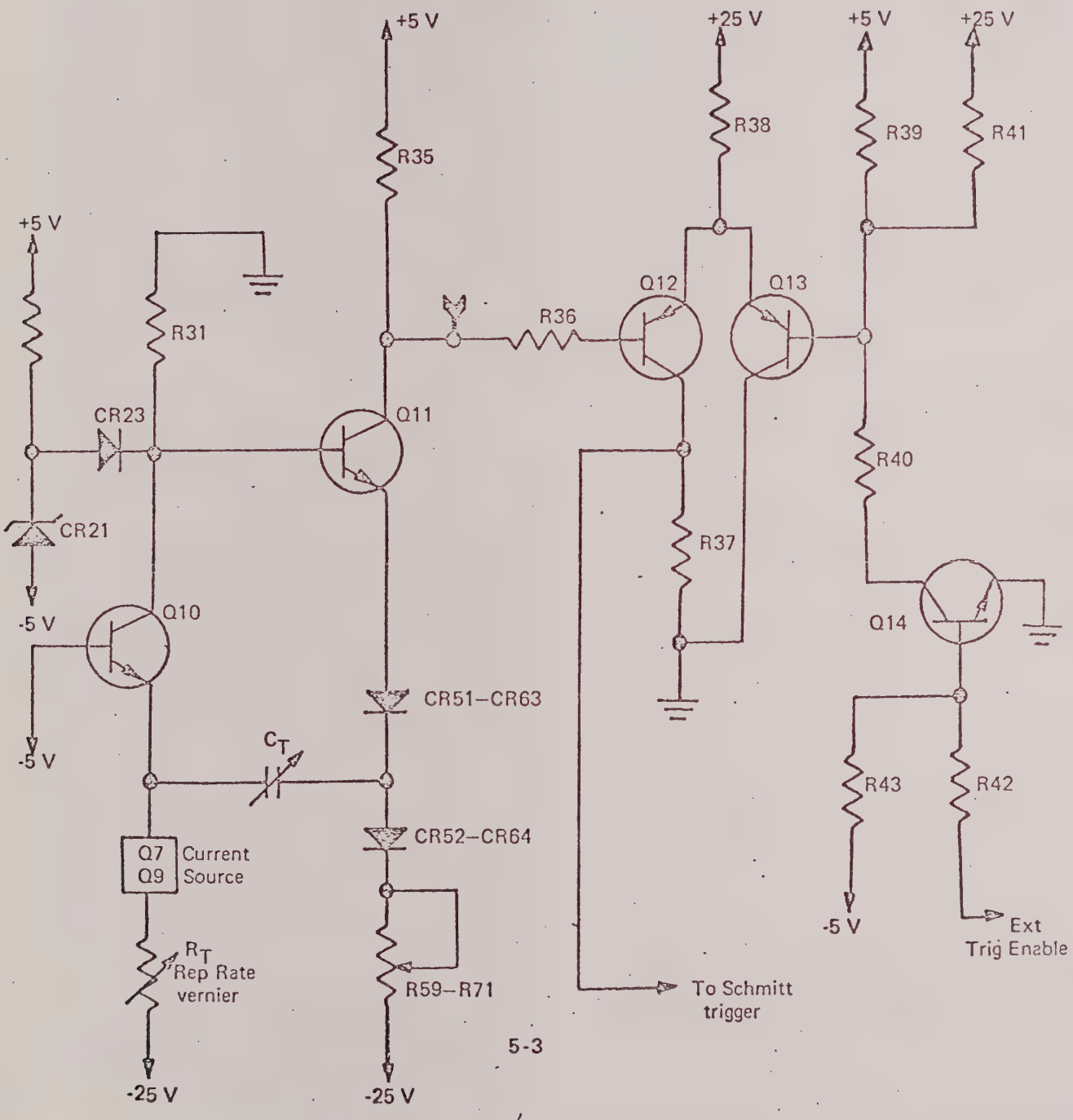


Figure 5-2. Rep Rate Multivibrator

tors, C52 through C61, represented by C_T in the simplified schematic, are located in the repetition rate decoder. Potentiometer R_T represents either the programming source vernier control or the front panel thumbwheels.

Transistors Q10 and Q11 are alternately turned on and off by feedback through timing capacitor C_T. At initial power on, either transistor may be conducting, therefore, for purposes of analysis, assume that Q10 has just turned off. Its collector and consequently the base of Q11 are at ground which causes Q11 to conduct. The current (from the current source) which formerly flowed through Q10, begins to charge C_T. The charging of C_T causes the emitter of Q10 to go negative. When the voltage is negative enough to forward bias Q10, it conducts. Both the collector of Q10 and the base of Q11 are driven sharply negative when Q10 conducts. Since the voltage across C_T cannot change instantaneously, the emitter of Q11 does not follow the base and Q11 remains cut off. Timing capacitor C_T, at the emitter of Q11 begins to discharge through one of the range resistors, R59–R71, depending on which range is selected. When the emitter of Q11 reaches approximately 0.6 V below the base voltage, it comes on again.

Diode CR23 clamps the collector of Q10 at approximately -3 volts and therefore prevents it from saturating. The current source for the repetition rate multivibrator is comprised of transistors Q7 and Q9. Potentiometer R21 is the zero frequency adjust and R32 is the maximum frequency adjust.

5.2.2 Schmitt Trigger

Trigger pulses either from an external source or from the repetition rate multivibrator are standardized into rectangular pulses, then differentiated and developed into a sharp positive spike by the Schmitt trigger. This sharp spike is used to drive the delay one-shot.

The incoming trigger pulses are fed to emitter follower Q30 then level detected by Z2. Uniform negative and positive rectangular pulses are developed at the outputs of Z2, pins 1 and 2. The positive-going rectangular pulse at pin 1 of Z2 is divided by the voltage divider comprised of R142 and R152 and coupled back to one of the inputs (pin 4) to establish the hysteresis of the level detector. The negative-going rectangular pulse at pin 2 is coupled to the input of the external trigger out amplifier.

Differential amplifier, Q31/Q32, R145 and L140 differentiate the rectangular pulse and at the collector of Q31 produces a negative-going spike followed by a positive-going spike. Only the negative spike causes Q33 to conduct, thereby developing a positive spike at its collector.

5.2.3 External Trigger

The external trigger circuit disables the output of the repetition rate multivibrator whenever external triggering is selected. When the instrument is in the internal trigger mode, Q18 supplies base current to Q21 which saturates and reverse biases CR86 and CR87. This prevents the output of differential amplifier Z2 from being coupled to the input of the Schmitt trigger. Also in the internal trigger mode, Q14 is on, making the base of Q13 approximately +4 volts. The pulse from the repetition rate multivibrator turns Q12 off when its base exceeds +4 volts and the pulse at the collector of Q12 is coupled through CR140 to the input of the Schmitt trigger.

External triggering is enabled when 0 volts is applied at circuit point [B5]. Transistors Q14 and Q18 are both turned off by this voltage. With Q14 off, the base of Q13 is at approximately +5.6 volts and the amplitude of the pulse from the repetition rate multivibrator does not go positive enough to turn Q12 off. Therefore, the collector of Q12 does not swing far enough in a negative direction to forward bias CR140 thereby preventing the repetition rate multivibrator output from triggering the Schmitt trigger. With Q18 off, CR86 or CR87 (depending on the trigger polarity) is forward biased, thus allowing the external trigger pulses to be coupled to the Schmitt trigger input.

Positive trigger polarity is enabled by applying 0 volts to circuit point (B7). This voltage turns Q19 and Q20 on and Q22 off. The conduction of Q19 reverse biases CR87 and the conduction of Q20 biases pin 11 of differential amplifier Z2 so that when a positive trigger is applied at the trigger input, the output is coupled through CR86 to the Schmitt trigger input. Negative triggering is enabled by applying +5 volts to circuit point (B7). Under this condition, Q22 is on and Q19 and Q20 are off. The conduction of Q22 reverse biases CR86 and with Q20 off, pin 11 of differential amplifier Z2 is biased so that when a negative trigger is applied at the trigger input, the output at pin 13 is coupled through CR87 to the Schmitt trigger input.

5.2.4 Sync Gate

When synchronous gating is enabled the current source for the repetition rate multivibrator is diverted from the timing capacitor until the application of the sync gate pulse.

To enable synchronous gating, Q2 is turned off and Q3 is turned on by applying 0 volts at circuit point (B4). With transistor Q3 on, base current is supplied to Q5 which conducts and supplies emitter current for differential amplifier Q1/Q4. The left hand half of the differential amplifier Q1 is conducting with no sync pulse applied since its base is more negative than the base of Q4. The conduction of Q1 forward biases Q6 which conducts and diverts the current source for the repetition rate multivibrator to ground.

When the sync gate pulse is applied to the sync input, Q1 is turned off, which turns Q6 off and the current source is allowed to flow to this timing capacitor.

5.2.5 Async Gate

The async gate circuit is comprised of differential amplifier Z2B and gate enable transistor Q24. When asynchronous gating is enabled, the Schmitt trigger output is blocked until the application of the gate signal.

In non-gated operation, transistor Q8 is biased on by the high state (approximately +2 volts) of differential amplifier Z2B. When async gating is enabled, transistor Q24 is biased on. With Q24 conducting, the input at pin 5 of Z2B is approximately ground, resulting in the output at pin 8 being approximately -0.5 volts. Transistor Q8 is then turned off and the base of Q32 is biased to +1.5 volts. Therefore the trigger at the base of Q31 does not have enough amplitude to overcome the bias at the base of Q32. Applying a positive gate signal to the async gate input turns Q8 on for the time interval of the gate signal and the trigger is passed by differential amplifier, Q31/Q32.

5.2.6 Trigger Out Amplifier

The trigger output amplifier is comprised of two stages of differential amplification, separated by a delay line and an emitter-follower output.

The rectangular pulse from the output of Z2C (pin 2) is differentiated by C120 and R121. The negative-going (leading edge) spike is amplified by differential amplifier Q25/Q26. However, the positive-going (trailing edge) spike is rejected since Q26 is already off. The amplified spike from Q26 is delayed by delay line DL120 and inverted by differential amplifier Q27/Q28. The positive-going spike at the emitter of Q29 is coupled to the back panel as the trigger output.

5.2.7 Delay One-Shot

Figure 5 - 3 is a simplified schematic of the delay one-shot. Transistor array Z3 is an integrated circuit, therefore transistor reference designations are assigned to facilitate the explanation.

The basic circuit of the delay one-shot is a monostable multivibrator. When the one-shot is triggered by a positive pulse it shifts to its unstable state and remains there for the length of time determined by the timing capacitor and the setting of the delay vernier.

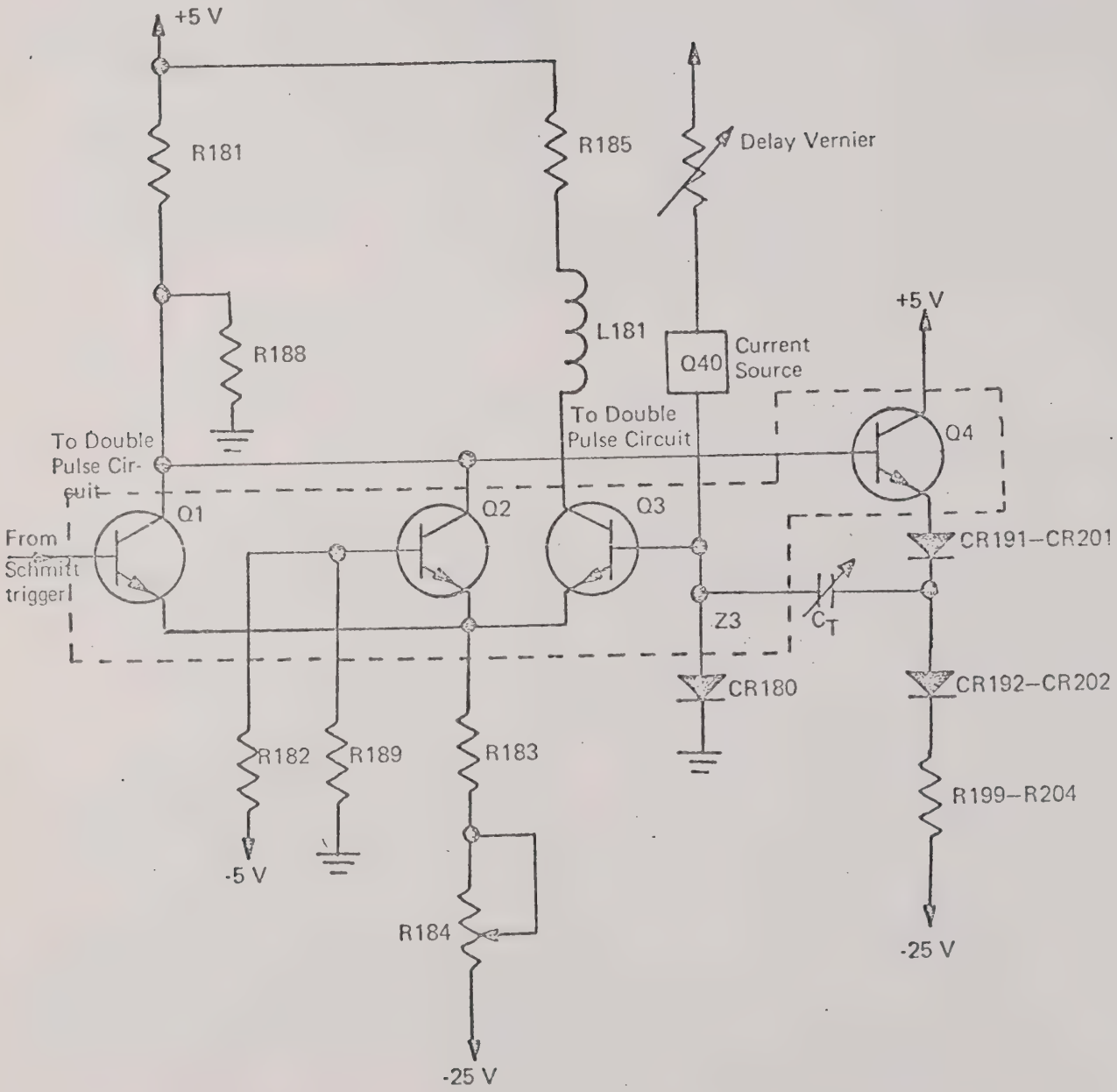


Figure 5-3. Delay One-Shot

Between pulses, Q1 is off and Q3 is on since its base is at approximately 0.6 volts. The positive pulse from the Schmitt trigger turns Q1 on, developing a negative-going pulse at its collector which is coupled through Q4 and C_T to the base of Q3. Transistor Q3 is turned off by this pulse and remains off while current source Q40 charges C_T positively. When the charge on C_T is positive enough to forward bias Q3, it turns on and Q1 turns off in preparation for the next trigger. During the cycle of operation a negative-going rectangular pulse is produced at the collector of Q1, a positive rectangular pulse at the collector of Q3. The time interval between the leading and the trailing edge of the pulse corresponds to the set delay.

Diode CR180 establishes the bias on Q3. Potentiometer R184 is the maximum delay calibration adjustment and L181 equalizes the width of the pulse at the collector of Q3 with the width of the pulse at the collector of Q1.

5.2.8 Double Pulse

The double pulse circuit is comprised of differential amplifier Q38/Q39 and logic transistors Q35 through Q37. The function of this circuit is to develop two sharp positive pulses; one at the beginning of the delay period and the other occurring at the end of the set delay period. In the single pulse mode only the delayed pulse drives the width one-shot, however, in the double pulse mode both the delayed and undelayed pulse drives the width one-shot.

The two rectangular pulses from the delay one-shot (negative at the base of Q38 and positive at the base of Q39) simultaneously turn transistor Q38 on and Q39 off. The pulses developed at the collectors of Q38 and Q39 are differentiated by L160/R165 and L161/R166 respectively. Diodes CR162 and CR163 allow only the positive spikes of the differentiated pulses to be coupled to the input of the width one-shot. The positive spike on the collector of Q38 occurs at the beginning of the delay period and the positive-going spike at the collector of Q39 occurs at the end of the delay period.

Single pulse mode is enabled by forward biasing Q37 with +5 volts at circuit point [CO]. With Q37 conducting, both Q36 and Q35 are turned on. The collector current in Q35 causes a voltage drop of approximately -0.6 volts across CR160. This voltage drop reverse biases CR161 and blocks the pulse on the collector of Q38.

5.2.9 Width One-Shot

The width one-shot is a monostable multivibrator that operates the same as the delay one-shot. The period of time that it remains in its unstable condition corresponds to the set pulse width. Rectangular pulses are developed at pins 1 and 5 of Z5. These pulses drive the normal/complement amplifier.

5.2.10 Normal/Complement Amplifier

The normal/complement amplifier, comprised of differential amplifiers Q49/Q51 and Q50/-Q52 and logic transistors Q48, Q53 and Q54, determines the polarity of the main output pulse by switching the polarity of the pulses at circuit points [AF] and [AG].

When the normal mode is enabled Q54 is turned on by +5 volts at circuit point [B8]. With Q54 conducting, base current is supplied to Q53 which conducts and supplies emitter current to differential amplifier Q50/Q52. The conduction of Q53 also makes the voltage at the base of Q48 approximately -25 volts which prevents it from conducting. The positive and negative pulse at the bases of Q50 and Q52 respectively, simultaneously turn Q50 on and Q52 off, thereby developing a negative-going pulse at circuit point [AG] and a positive-going pulse at circuit point [AF].

In the complement mode, Q54 is turned off by 0 volts at circuit point [B8]. With Q54 not conducting, Q53 is off and Q48 is on since it is forward biased by the voltage developed by the voltage divider consisting of R252 and R253. The positive pulse at the base of Q51 turns it off, resulting in a negative-going pulse at circuit point [AF] and a positive-going pulse at circuit point [AG].

Transistor Q55 is a voltage source that supplies collector voltage for Q49 through Q52 and bias voltage for the input stage of the output amplifier.

5.2.11 Rep Rate, Width and Delay Decoder

The operation of the three decoders are identical. The decoders determine which timing capacitor is utilized in the multivibrator circuit. A three digit BCD input to the three input transistors enable the logic circuit (Z1, Z4 or Z6) which selects the timing capacitor and resistor. Refer to Figure 2-2 or 2-3 for the BCD inputs.

5.2.12 V_{UL}/V_{LL} Control

Refer to Schematic 40000-412 and Figures 5-4 and 5-5 for the following explanation.

The V_{UL}/V_{LL} control circuit develops the upper and lower level voltage for the clamp diodes in the output amplifier and thereby control the amplitude of the output pulse. Both V_{UL} and V_{LL} are variable from 0 to +10 volts or 0 to -10 volts. Since the operation of the V_{UL} and V_{LL} circuits are the same, only the V_{UL} circuit will be explained.

The input for the V_{UL} circuit is at the emitter of Q1. This positive input voltage from the V_{UL} D/A converter causes emitter current to flow in Q1 since its base is at approximately 3.2 volts. When the V_{UL} D/A converter is set for maximum upper level voltage (10 volts) the input to Z1 pin 5 is approximately 3.5 volts. Since Z1 is connected as a voltage follower, the output amplitude is the same as the input. This voltage is amplified by Z91, which has a gain of approximately 3 or -3, depending on the range selected. The polarity of the output voltage from Z91 is determined by whether the input voltage is to pin 4 (inverting input) or pin 5 (non-inverting input).

Figure 5-4 shows a simplified schematic of the range and polarity selection portion of the V_{UL}/V_{LL} control circuit. Range and polarity selection is accomplished by setting the program lines according to the truth table on Schematic 40000-412. Logic circuit Z41 turns on the corresponding transistor for the range selected. Figure 5-5 shows the configuration of operational amplifier Z91 and the equations for each V_{UL} range and polarity.

Transistors Q91 and Q92 protect Z91 from excess current drain. Diode CR101 compensates for the voltage drop in the clamp diode in the output amplifier. Zener diode CR99, diode CR100 and the base-emitter junctions of Q91, Q92, Q111 and Q112 limit the maximum difference between V_{UL} and V_{LL} to approximately 11.5 volts. Diodes CR93 through CR98 protect against damage in case V_{LL} is set more positive than V_{UL}.

5.2.13 Variable Rise/Fall Power Supply (Model 154 only)

5.2.13.1 General Description

Refer to Schematic 40000-551 and simplified Block Diagram, Figure 5-6 for the following explanation.

The rise/fall power supply develops the charging current for the rise/fall capacitors in the output amplifier. Only the differences between the fall and rise time sections will be discussed as the circuits operate in a similar manner (the rise time circuit supplies positive current and the fall time circuit supplies negative current).

The inputs from the D/A cards are in the form of a conductance which varies proportional to the digital word. The other inputs are V_{UL} and V_{LL}, signals which vary with output amplitude settings.

The combination of these signals causes the rise and fall times to remain constant with amplitude (refer to the simplified presentation of the rise/fall circuit shown in Figure 5-6a).

Assuming a positive charge cycle, the voltage V_c will start at approximately V_{LL} and increase

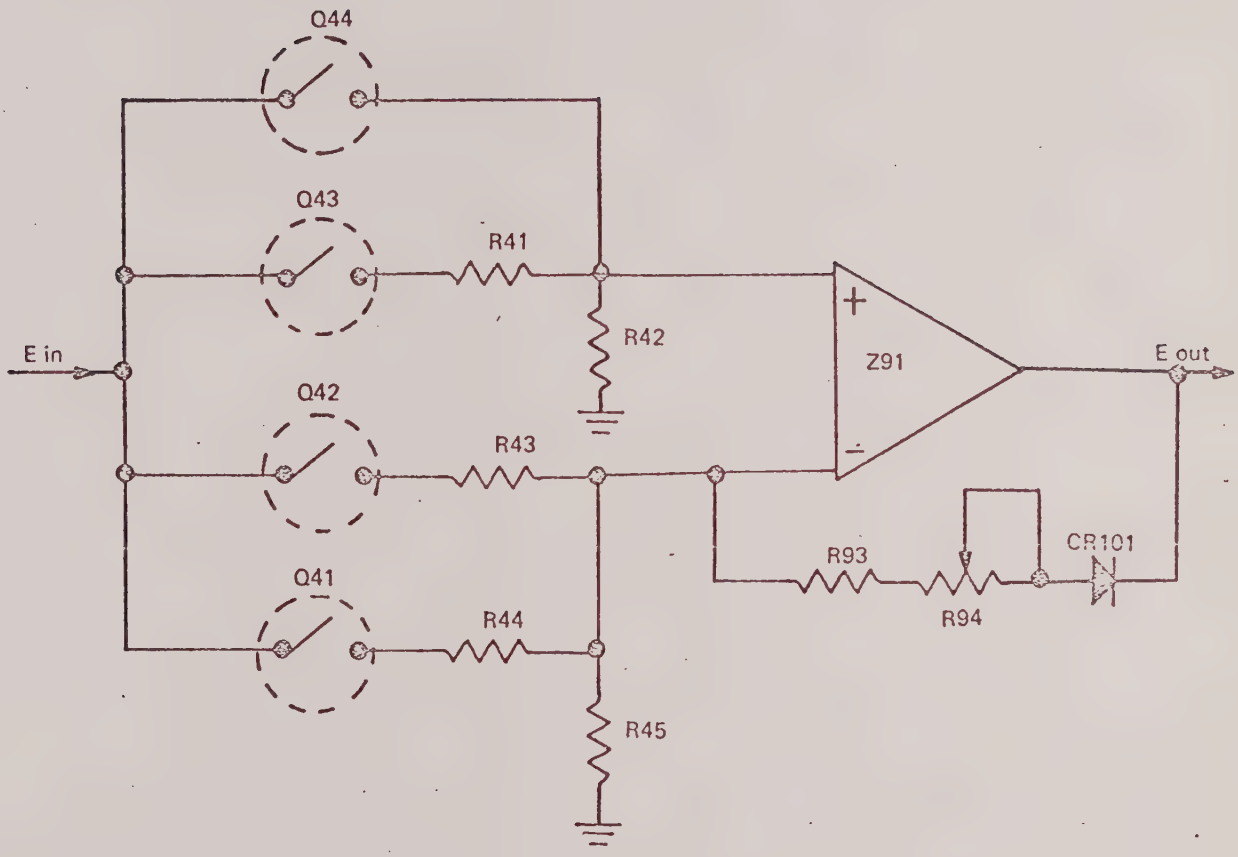


Figure 5-4. V_{UL} Range and Polarity Selection Circuit

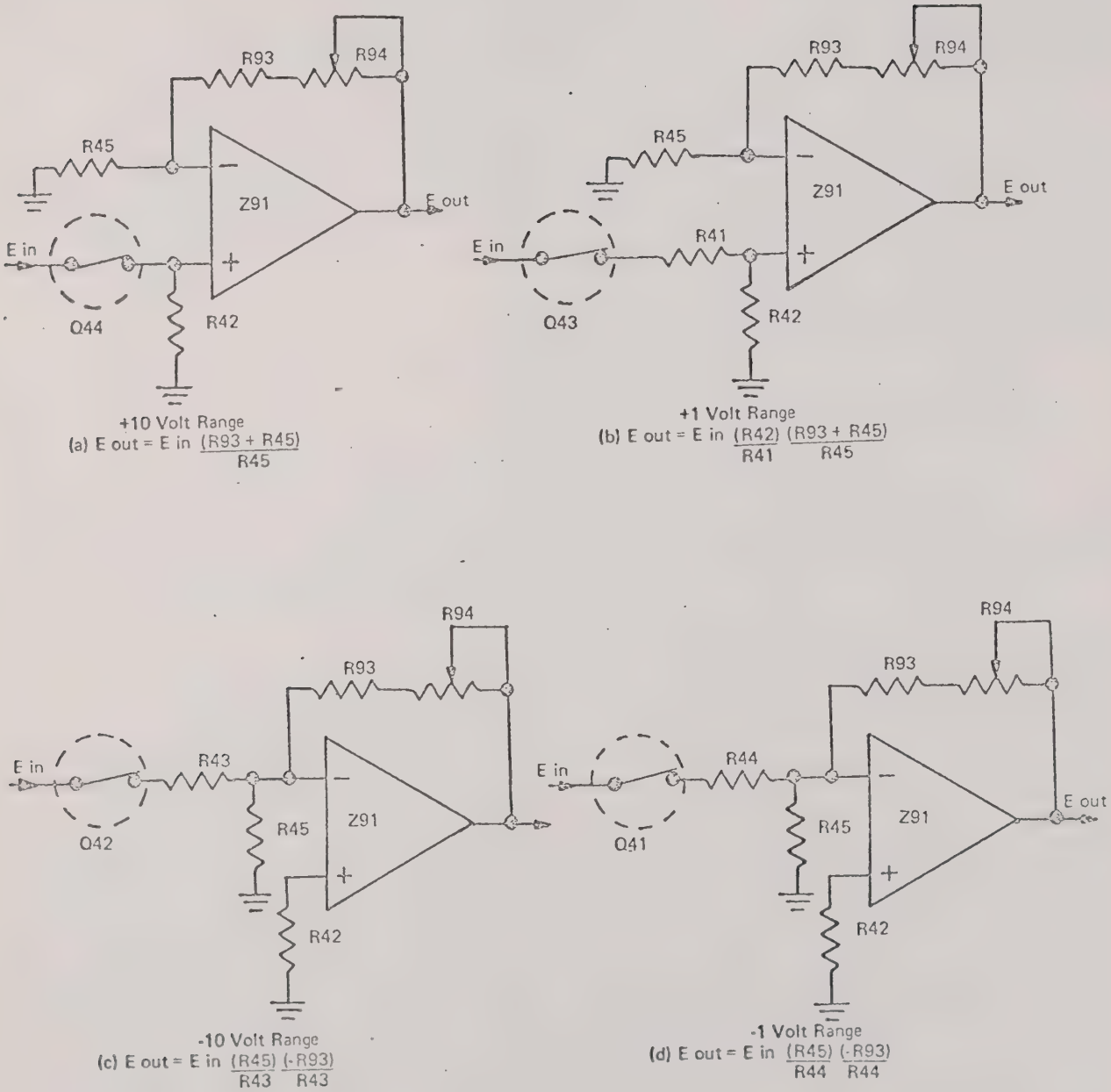


Figure 5-5. Detailed Range and Polarity Selection Circuit

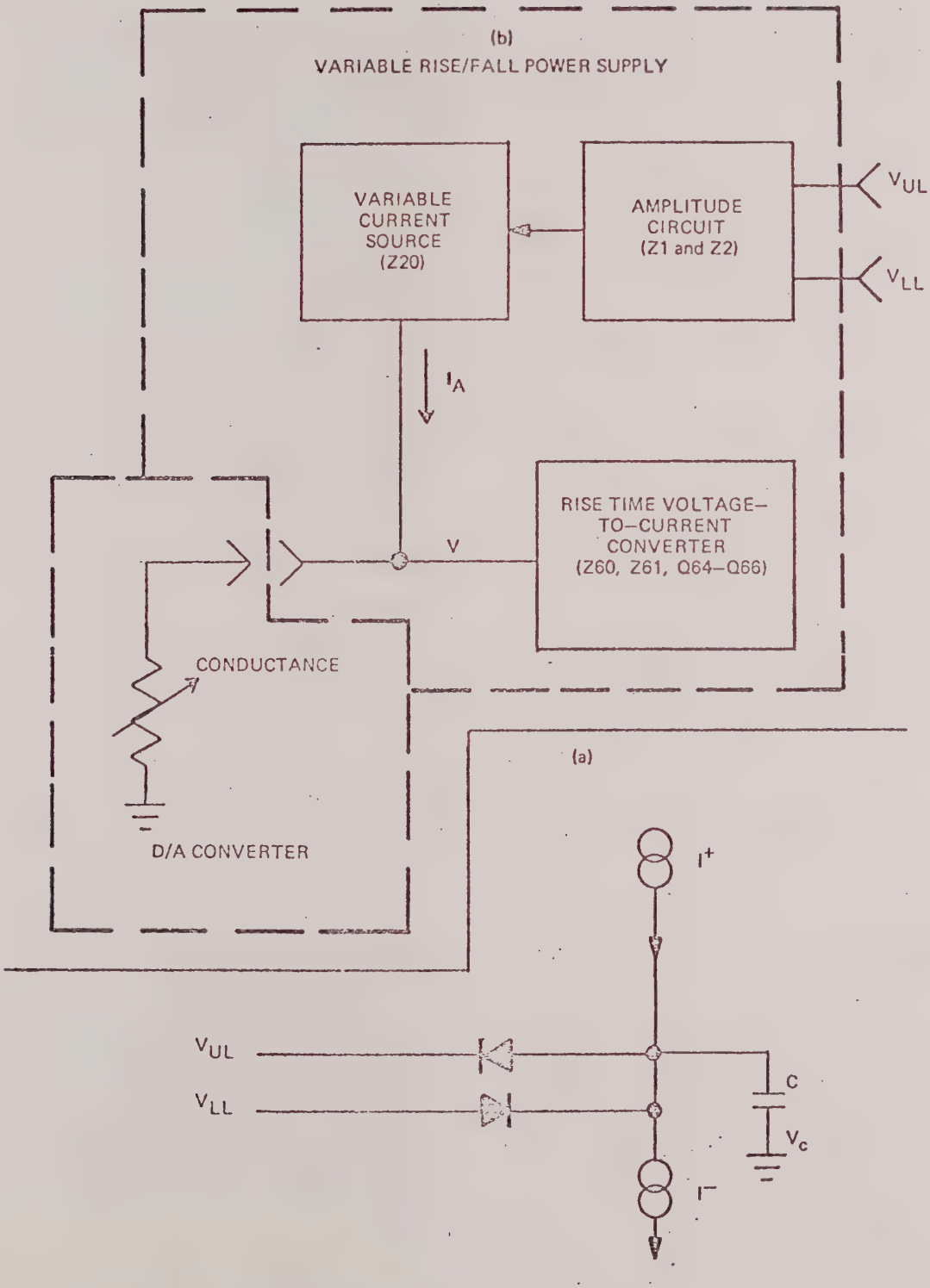


Figure 5-6. Simplified Block Diagram

until the V_{UL} voltage level (approximately) is reached. The charge rate is determined by the current I_+.

The charge time then is (for I_+ constant):

$$T_+ = V_c \times C/I \text{ (equation 1)}$$

To keep T_+ constant, I_+ must vary proportionally to V_c ($I_+ \propto V_c$).

The rise/fall power supply accomplishes the function of keeping I_+ constant (as shown in Figure 5 - 6b).

The V_{UL} and V_{LL} signals are subtracted ($V_{UL}-V_{LL}$) to give a signal proportional to amplitude. This signal is fed into a current source, causing its current output to vary proportional to the amplitude of the input from Z2. This current drives a resistance (R) on the D/A card to develop a voltage delivered to the current converter and thus provides I_+ to the output amplifier.

The resistance (R) is inversely proportional to the time (T_+) selected by the program (or front panel), thus the voltage $V = I_A R$ is also inversely proportional to the setting.

I_+ is then developed by the voltage to current converter and $I_+ \propto I_A R$ substituting in equation (1), we develop a new expression:

$$T_+ \propto (V_c \times C)\, I_A R \text{ (equation 2)}$$

As $V_c \propto$ amplitude and $I_A \propto$ amplitude, T_+ then becomes proportional to C and R, only.

$$T_+ \propto C/R \text{ (equation 3)}$$

As I/R is proportional to settings and C is constant,

$$T_+ \propto \text{setting (equation 4)}$$

and therefore the rise time is independent of amplitude.

5.2.13.2 Detailed Circuit Description

Refer to Schematic 40000 - 551 and the simplified schematic in Figure 5 - 6 for the following explanation.

The inputs to the R/F power supply include V_{UL} and V_{LL} and the rise time and fall time signals. Any variation in these inputs results in variations in the voltage level applied to the Rise and Fall Time Voltage to Current Converters, with a resultant change in charging current supplied to the capacitors in the Rise/Fall Output Amplifier.

Differential amplifier Z1 compares the V_{UL} and V_{LL} inputs and develops an output proportional to the difference between these two inputs. The output of Z1 drives operational amplifier Z2; Z2 sets the scale factor and bias level of the signal driving variable current source Z20 (observable at TP3). Changes in the output level of Z2 cause Z20 to change the level of its current output (measured across R21 between TP1 and TP2).

The current output of Z20 develops a voltage across the conductance selected on the D/A converter card (paragraph 5.2.16 and 5.2.17).

This voltage (determined by the value of the selected conductance and the current from Z20) is supplied to pin 5 of the operational amplifier Z60 in the Rise Time Voltage to Current Converter.

Changes in voltage sensed at pin 5 of Z60 are amplified by Z60 and coupled through Q61 to operational amplifier Z61, which keeps the voltage at the emitter of Q65 at the proper level. This voltage determines the emitter and collector current of Q65 which supplies the rise time current output to the output amplifier. Transistor Q66 supplies current to diode CR101 in the V_{UL}/V_{LL} control circuit that is proportional (approximately one half) to the current supplied to the output amplifier. This current keeps the voltage drop across CR372 approximately equal to the drop across the clamp diode (R62/CR63) in the output amplifier.

For the 5—10 ns rise/fall time range, Q63 is held in a conducting state by a positive voltage from the output amplifier (through pin U of the Bay 2 connector). When the 5—10 ns range is selected, Q63 is turned on, thereby lowering the collector voltage of Q61, thus increasing the output current of Q65. In all other ranges Q63 is turned off.

Differences existing between the Rise Time and Fall Time Voltage to Current Converters will now be defined. Z80 is a voltage following buffer, Q80 provides temperature and offset compensation for the Hyperbolic Conductance D/A Card. Z81 performs the same function as Z60 except that it inverts to provide negative current. The remainder of the Fall Time Voltage to Current Converter circuitry is essentially the same as that of the Rise Time Voltage to Current Converter except that all transistors are of opposite polarity due to the requirement for opposite currents.

5.2.14 Fixed Rise/Fall Output Amplifier (Model 153)

Refer to Schematic 40000 - 436 for the following explanation.

The output amplifier developes the amplitude and rise/fall times of the output pulse. The inputs to the output amplifiers at J425 and J426 are the timing pulses from the front end board (circuit points [AF] and [AG]). Diodes CR438 and CR433 are clamped by the upper level (V_{UL}) and lower level (V_{LL}) voltages respectively.

Transistors Q426 and Q430 are alternately turned off and on by the timing pulse from the front end board and Q427 and Q429 (connected in a cascade arrangement with Q426 and Q430) are driven by the pulse at the collectors of Q426 and Q430. The collector swing on Q434 is limited by clamp diodes CR433 and CR438. The current that determines the rise and fall times is supplied by the current source comprised of Q432 and Q435. This current is proportional to the difference between the upper level voltage at the base of Q425 and a compensated lower level voltage (V_{LL}—5 volts) at the base of Q428.

The amplitude of the pulse at the junction of the clamp diodes (CR438 and CR433) is approximately at the level of the output pulse. Aberrations are removed from the pulse top by operating parallel emitter followers, Q436/Q438 or Q437/Q439 (depending on the pulse polarity) near saturation. Parallel transistor combinations Q442/Q444 and Q441/Q443 are the current sources for the parallel emitter followers. Base voltage for the current sources is supplied by upper level (V_{UL}) and lower level (V_{LL}) voltages. Transistors Q448 and Q449 limit the current to complementary output transistors Q446 and Q447.

Collector voltage for Q427 and Q429 and emitter voltage for Q442 and Q444, which is V_{LL}— 5 volts, is developed by diode CR439 and zener diode CR440 and supplied at the emitter of Q440. Emitter voltage for Q441 and Q442, and base voltage for Q433 which is V_{UL} +5 volts, is developed by diode CR436 and zener diode CR437 and supplied at the emitter of Q445. Diodes CR450 through CR452 and CR455 through CR457 are part of the overvoltage protection circuit described in paragraph 5.2.12. They prevent damage if the upper and lower levels are set more than 11.5 volts apart.

5.2.15 Variable Rise/Fall Output Amplifier (Model 154)

Refer to Schematic 40000 - 438 for the following explanation.

The output amplifier develops the amplitude and rise/fall times of the output pulse. The inputs to the output amplifier at J1 and J2 are the timing pulses from the front end board (circuit points [AE] and [AG]). Diodes CR62/CR63 and CR64 are clamped by the upper level (V_{UL}) and lower level (V_{LL}) voltage respectively, thereby determining the upper and lower levels of the output pulse.

Transistors Q11 and Q12 are alternately turned off and on by the timing pulses from the front

end board. Differential amplifiers Q13/Q14 and Q15/Q16 alternately drive current switching amplifiers Q18/Q19 and Q20/Q21 respectively to develop the rise/fall times of the pulse. Current sources Q22 and Q17 supply the positive and negative current to charge the rise/fall time capacitors (C4, C5, C7, C8, C10 and C11). The amount of current flowing in these two sources is determined by the rise/fall power supply (see paragraph 5.2.12).

The heart of the output amplifier (the rise/fall circuit) is illustrated in simplified form in Figure 5 - 7. When the polarity of timing pulses are as shown in Figure 5 - 7, Q18 and Q21 are conducting. The rise/fall timing capacitor (C4/5, C7/8 or C10/11) is charged negatively by the current through Q21. When the voltage on the capacitor goes negative enough to forward bias clamp diode CR64, the charging current is shunted through the diode. The capacitor maintains the negative charge until the polarity of the timing pulses change at which time transistors Q19 and Q20 are turned on. With Q20 on, the timing capacitor is charged in a positive direction until clamp diode CR62/CR63 is forward biased.

The amplitude at the junction of clamp diodes CR62/CR63 and CR64 is approximately at the level of the output pulse. Aberrations are removed from the pulse top by operating emitter-follower Q27 or Q26 (depending on the pulse polarity) near saturation. Transistor combinations Q24/Q25 and Q28/Q29 are the current sources for emitter-followers Q26 and Q27. Base voltage for these current sources is supplied by the upper and lower level voltages. Transistors Q33 and Q36 supply the current to complementary output transistors Q34 and Q35.

Collector voltage V_{UC} (V_{UL} +5 volts) for differential amplifiers Q13/Q14 is developed by diode CR83 and zener diode CR82 and supplied at the emitter of Q23. Collector voltage V_{LC} (V_{LL}— 5 volts) for differential amplifiers Q15/Q16 is developed by diode CR92 and zener diode CR93 and supplied at the emitter of Q30. Diodes CR101 through CR106 are part of the overvoltage protection circuit described in paragraph 5.2.12. They prevent damage if the upper and lower levels are set more than 11.5 volts apart.

The alternate charging of the timing capacitor develops the pulse as shown at point A.

Selection of the rise/fall range is accomplished by turning on either Q6, Q8 or Q10 thereby supplying a charging path for the timing capacitor on the collector. The 5—10 ns range has no range capacitor. An explanation of how the 10—100 ns range is selected will serve to illustrate the operation of the logic circuit.

In order to select the 10—100 ns range 0 volts is applied at line 1 and +5 volts at line II. Under this condition, transistor Q1 is biased off and Q3 is biased on. With Q1 off, Q2 is conducting and with Q3 conducting Q4 is off. Therefore, the cathode of the gate diodes will be as follows: CR9 and CR10 both +5 volts; CR11 and CR12 both ground; CR13 ground and CR14 +5 volts. With the gate diodes in this voltage configuration, Q8 and Q10 are off and Q6 is on, supplying a charging path for capacitor C5, thereby selecting the 10—100 ns range.

5.2.16 Hyperbolic D/A Converter (Schematic 40000-482)

The hyperbolic D/A converter shown in simplified form in Figure 5-8 changes the 12-bit digital inputs into current levels required by the delay and width circuits. Each of the 12-bits set the state of switching transistors Q2—Q24 (even numbers). When the bit is true the transistor is on and its collector resistor is placed in parallel with resistors R65 and R66. Current source Q27 supplies current to this parallel combination. Since operational amplifier Z8 is connected as a comparator, the voltage drops across the parallel combination and R71/R72 are equal and the amount of current that flows through R71/R72 is proportional to the current that flows through Q28 to the D/A converter output.

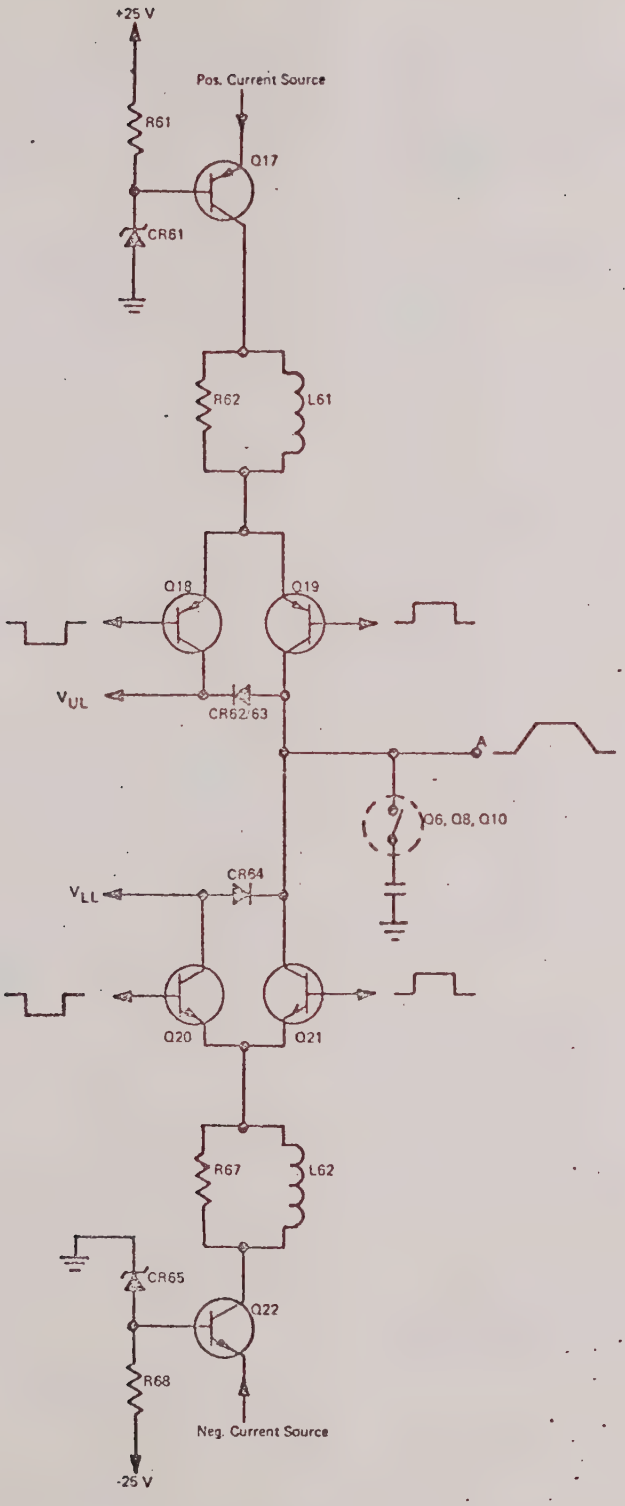


Figure 5-7. Rise/Fall Output Amplifier Circuit

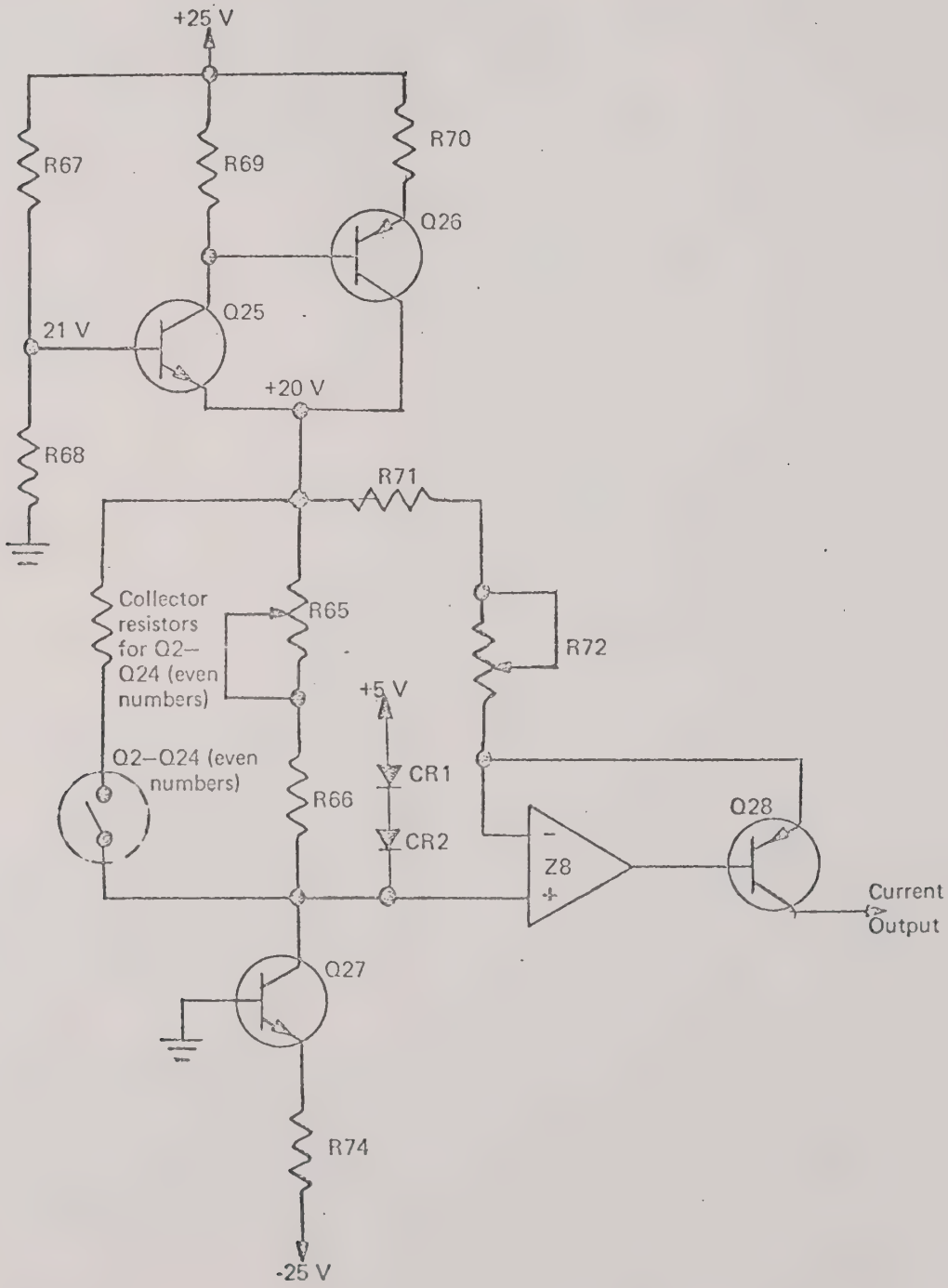


Figure 5-8. Hyperbolic D/A Converter

Transistors Q25 and Q26 comprise a voltage source that supplies approximately 20 volts at R71. Clamp diodes CR1 and CR2 prevent pin 5 of Z8 from going below 3 volts. Diodes CR3 and CR4 prevent Z8 from latching up.

In instruments that have serial data inputs, bi-stabled latches Z4–Z7 hold switching transistors Q2–Q24 in the state determined by the data inputs. The bi-stable latches are enabled by strobe A and B. When the instrument is controlled by the front panel switches, +5 V AUTO is removed thereby disabling Z4–Z7.

In instruments that have parallel data inputs, line drivers Z1–Z3 actuate switching transistors Q2–Q24.

5.2.17 Hyperbolic Conductance D/A Converter

Refer to Schematic 40000 - 550 for the following explanation.

The hyperbolic conductance D/A converter changes the 12-bit (3-digit BCD) digital input into a conductance (1/resistance) proportional to the digital word. Each of the 12-bits sets the state of a switching transistor (Q1 through Q12) into BCD format. When the input bit to converters Z8 or Z9 is true (ground), the corresponding transistor is turned on, and the associated conductor is essentially grounded. The number of transistors turned on determines the value of conductance obtained.

As an example, if the MSD were 1 the transistor Q1 would be on and the conductance would be approximately 1/10.2 k. If the MSD were 2, Q2 is on and the conductance is approximately 1/5.1 k. Thus it can be seen that the value of conductance was doubled (the resistance halved) illustrating the proportionality of the conductance and thus the inverse (hyperbolic) proportionality of the resistance.

In instruments that have serial data inputs, bi-stabled latches Z4–Z7 hold switching transistors Q2–Q24 in the state determined by the data inputs. The bi-stable latches are enabled by strobe A and B. When the instrument is controlled by the front panel switches, +5 V AUTO is removed thereby disabling Z4–Z7.

In instruments that have parallel data inputs, line drivers Z1–Z3 actuate switching transistors Q2–Q24.

5.2.18 Linear D/A Converter

Refer to Schematic 40000 - 481 for the following explanation.

The linear D/A converter changes the 12-bit digital inputs into current levels required by the repetition rate multivibrator and V_{UL}/V_{LL} control circuit. The switching transistors (Q1–Q12) are on when the data bit is false. When the data bit is true the switching transistor is off. The number of transistors that are not conducting determines the amount of current that flows in the output.

5.2.19 Serial to Parallel Converter (Model 153/154–3)

The serial to parallel converter receives 12 line serial data from the programming source, and through the use of addresses, programs each pulse parameter and selects the mode of operation.

The eight data bits are fed through line drivers, Z1, Z2 and Z3 to the data inputs of the D/A converter (see Schematic 40000 - 487). The four address bits and the clock input enable quad-NAND gate Z5 which drives BCD-to-decimal decoders Z7 and Z8. The decoded outputs Z7 and Z8 are inverted and become the strobes for the parameter selected by the address.

The clock input is delayed approximately 200 ns by one-shot multivibrator Z6 and is fed to rear panel connector J1 as delayed clock out.

5.2.20 Power Supply

Refer to Schematic 40000-417 for the following explanation.

The power supply consists of two nearly identical regulators, +25 and -25 volts, a +5 volt regulator that also supplies +2 volts and a -5 volt regulator. All of the voltage sources are series regulated, and all operate approximately the same. Therefore only the +25 volt regulator will be explained.

Rectified and filtered voltage is supplied to the collector of Q502. Reference for the regulator is provided by zener diode Z501 and R510 is adjusted so that the inputs to error amplifier Z501 are equal. Any errors occurring at the supply output is sensed across R510, resulting in a voltage change in the opposite polarity at the output of Z501. Assuming that the output voltage has decreased (gone negative) the voltage at the output of Z501 increases (goes positive). This positive-going voltage increases the current through series pass transistors Q502 and Q503 which cause the output voltage to increase.

Over-current protection is provided by transistor Q504. When an over-current condition occurs, Q504 is forward biased by the voltage drop across R504. Transistor Q504 conducts and the over-current is shunted away from the series pass transistors. When the over-current condition is removed the regulator is restored to normal operation.

PARTS LIST

SECTION VI

PARTS LIST

6.1 ABBREVIATIONS and SYMBOLS

6.1.1 Reference Designations

Reference designations in this parts list corresponds to the circuit symbols used in the following schematics:

Drawing Number		
	40000-421	40000-481
	40000-412	40000-482
	40000-558	40000-550
	40000-444	40000-483
	40000-551	40000-486
	40000-436	40000-487
	40000-438	40000-417

6.1.2 Abbreviations

ampere	A
binery-coded-decimal	BCD
capacitor	C
clockwise	cw
counterclockwise	ccw
concentric	conc.
double pole	dp
fuse	F
indicator lamp	DS
integrated circuit	ZnIC
jack	J
kilohm	k
megohm	M
microfarad	μF
millivolts dc	mV dc
quadruple	quad
resistor	R
single-pole-double-throw	SPDT
switch	S
transformer	T
transistor	Q
variable	Var.

6.1.2 Abbreviations (cont.)

volts	V
volts ac	V ac
volts dc	V dc
watts	W

6.1.3 Manufacturers

Allen Bradley Company	AB
Alco Electronic Products	Alco
Amphenol RF Division	Amphenol
American Components Incorporated	ACI
Arco Electronics Incorporated	Arco
Beckman Instruments	Beckman
Bussman Manufacturing Company	Buss
Components Incorporated	Comp
Centralab Electronics Division	Centralab
Continental Wirt	CW
Corning Glass Works	Corning
Datapulse Division Systron-Donner Corporation	DP
Delevan Components Corporation	Delevan
Electro-cube Incorporated	Electrocube
Electra Manufacturing Company	Electra
Erie Technological Products Incorporated	Erie
Ferroxcube Corporation	Ferroxcube
Fairchild Semiconductor Products Incorporated	FT
HP Associates	HPA
IMB Electronic Products	IMB
IMC Magnetics Corporation	IMC
International Rectifier Corporation	IRC
Liberty Electronics Incorporated	Liberty

6.1.3 Manufacturers (cont.)

GS Marshall Company	GSM
Motorola Semiconductor Products Incorporated	Mot.
Nashville Electronics Corporation	Nashville
Ohmite Manufacturing Company	Ohmite
Radio Corporation of America	RCA
Sangamo Electric Company	Sangamo
Semcor Division of Components Incorporated	Semcor
Sprague Electric Company	Sprague
STM Corporation	STM
Sylvania Electric Products Division	Syl.
Texas Instruments	TI
Varadyne Incorporated	Varadyne
Wilco Corporation	Wilco

6.2 FRONT PANEL ASSEMBLY

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Model 153—1 P/N37000-946					
Model 153—3 P/N37001-168					
Model 154—1 P/N37000-948					
Model 154—3 P/N37001-182					
S501	15280-001	1	Switch, SPDT	Alco	MST 1050
DS1	15450-035	1	Lamp Cartridge, Green	Eldema	39-28-1472
	15270-017	1	27 Station Thumbwheel Switch Assembly (parts listed below in assembly order)	DP	
	(MODEL 154—1 and 3)				
1.	15270-045		LH End Bracket		
2.	15270-026		Module		
3.	15270-028		Module		
4.			Same as 3		
5.	15270-035		Module		
6.	15270-043		0.250 Wide Spacer		
7.			Same as 2		
8.			Same as 3		
9.			Same as 3		
10	15270-036		Module		
11.			Same as 6		
12.			Same as 2		
13.			Same as 3		
14.			Same as 3		
15.			Same as 10		
16.			Same as 6		
17.	15270-027		Module		
18.			Same as 3		
19.			Same as 3		
20.	15270-037		Module		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
21.			Same as 2		
22.			Same as 3		
23.			Same as 3		
24.			Same as 6		
25.			Same as 2		
26.			Same as 3		
27.			Same as 2		
28.	15270-038		Module		
29.			Same as 6		
30.			Same as 2		
31.			Same as 3		
32.			Same as 2		
33.			Same as 28		
34.	15270-044		RH End Bracket		
	15270-016	1	20 Station Thumbwheel Switch Assembly (parts listed below in		
	(Model 153—1 and 3)		assembly order)	DP	
1.	15270-045		LH End Bracket		
2.	15270-027		Module		
3.	15270-028		Module		
4.			Same as 3		
5.	15270-035		Module		
6.	15270-043		0.250 Wide Spacer		
7.	15270-026		Module		
8.			Same as 3		
9.			Same as 3		
10.	15270-036		Module		
11.			Same as 6		
12.			Same as 7		
13.			Same as 3		
14.			Same as 3		
15.			Same as 10		
16.			Same as 6		
17.			Same as 7		
18.			Same as 3		
19.			Same as 7		
20.	15270-039		Module		
21.			Same as 6		
22.			Same as 7		
23.			Same as 3		
24.			Same as 7		
25.			Same as 2		
26.	15270-044		RH End Bracket		

6.3 AUXILIARY SWITCH ASSEMBLY (P/N37001-082)

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
S730 thru S737	A15301-029	1	8 Bank Switch Assembly	DP	
CR731	22164-000	7	DP16-0/1N3600	DP	
CR732 thru CR737			Same as CR731		
	38000-434		Circuit Board		

6.4 FRONT END PCB ASSEMBLY (P/N37000-914)

C1	11241-223	39	0.022μF, 25 V	Sprague	HY525
C2			Same as C1		
C20			Same as C1		
C21			Same as C1		
C22			Same as C1		
C23	11491-476	3	47μF, 15 V	Sprague	196D476X020LA1
C24			Same as C1		
C25			Same as C23		
C26	11490-107	1	100μF, 10 V, 20%	Comp.	TD5-10-107-20
C27			Same as C1		
C50			Same as C1		
C51			Same as C1		
C52	11077-220	3	22 pF, 500 V, 5%	Arco	DM15E2204
C53	11307-110	3	Var., 2.5, 11 pF, 200 V	Erie	538-014-903
C54	11077-221	1	220 pF, 500 V, 5%	Arco	DM15-2214
C55	11309-600	3	15–60 pF, 200 V	Erie	538-011-P3PO-112R
C56	11079-302	1	3000 pF, 500 V, 1%	Arco	DM19CM06F302F03
C57	11124-383	3	0.033μF, 200 V, 2%	Electrocube	210B1C333G
C58	11124-334	3	0.33μF, 200 V, 2%	Electrocube	210B1C334G
C59	11522-335	3	3.3μF, 35 V, 5%	Kemet	K3R3C35D
C61	11520-336	1	33μF, 10 V, 10%	Sprague	150D336X5010B2
C63			Same as C23		
C80	11073-102	2	1000 pF, 100 V, 5%	Arco	DM15E102J
C81			Same as C1		
C82			Same as C1		
C83			Same as C1		
C84			Same as C1		
C85			Same as C1		
C101			Same as C1		
C120	11077-101	1	100 pF, 500 V, 5%	Arco	DM15E101J
C121			Same as C1		
C122			Same as C1		
C123			Same as C1		
C124			Same as C1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C125			Same as C1		
C140			Same as C1		
C141			Same as C1		
C142			Same as C1		
C144	11492-685	2	6.8μF, 35 V, 20%	Sprague	196D685X0035KA1
C145			Same as C144		
C160			Same as C1		
C180			Same as C1		
C181			Same as C1		
C182			Same as C1		
C190			Same as C1		
C191			Same as C52		
C192			Same as C53		
C193	11017-301	2	300 pF, 500 V, 5%	Sangamo	E301J
C194			Same as C55		
C195	11079-332	2	3300 pF, 500 V, 1%	Arco	CM06F332F03
C196			Same as C57		
C197			Same as C58		
C198			Same as C59		
C200			Same as C1		
C210			Same as C1		
C211			Same as C80		
C212			Same as C1		
C213			Same as C1		
C214			Same as C1		
C230			Same as C1		
C231			Same as C52		
C232			Same as C53		
C233			Same as C193		
C234			Same as C55		
C235			Same as C195		
C236			Same as C57		
C237			Same as C58		
C238			Same as C59		
C240			Same as C1		
C250			Same as C1		
C251			Same as C1		
C252			Same as C1		
C253			Same as C1		
L20	14244-000	1	3.6μH	Ferroxcube	VC200-20/4B
L21	14284-012	2	0.15μH	Delevan	1025-00
L54	14284-010	1	0.1μH	Delevan	1025-94
L55	14284-008	2	0.22μH, 10%	Delevan	1025-04
L56	14284-014	4	0.47μH	Delevan	1025-12

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
L119			Same as L56		
L121			Same as L21		
L140	14284-011	1	0.33μH	Delevan	1025-08
L160			Same as L56		
L161	14284-016	1	0.56μH	Delevan	1025-18
L181			Same as L55		
L211			Same as L56		
Q1	A22605-008	11	DP608	Mot.	DP608
Q2	12635-998	7	2N3641	FT	2N3641
Q3			Same as Q2		
Q4			Same as Q1		
Q5	12605-005	5	2N3638	FT	2N3638
Q6	A22635-003	13	DP633	DP	2N2369A
Q7	12785-000	1	MPS A65	Mot.	MPS A65
Q8			Same as Q6		
Q9	12745-000	1	TD101	Sprague	TD101
Q10	12645-013	2	2N5179	RCA	2N5179
Q11			Same as Q10		
Q12			Same as Q1		
Q13			Same as Q1		
Q14	12695-007	1	TZ82	Sprague	TZ82
Q15	12605-014	11	2N5087	Mot.	2N5087
Q16			Same as Q15		
Q17			Same as Q15		
Q18			Same as Q2		
Q19			Same as Q1		
Q20			Same as Q5		
Q21			Same as Q1		
Q22			Same as Q1		
Q24			Same as Q5		
Q25			Same as Q6		
Q26			Same as Q6		
Q27			Same as Q1		
Q28			Same as Q1		
Q29			Same as Q6		
Q30			Same as Q6		
Q31			Same as Q6		
Q32			Same as Q6		
Q33			Same as Q1		
Q34			Same as Q1		
Q35			Same as Q6		
Q36			Same as Q5		
Q37			Same as Q2		
Q38	12605-012	2	2N4258	FT	2N4258

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q39			Same as Q38		
Q40 thru Q47			Same as Q15		
Q48			Same as Q2		
Q49			Same as Q6		
Q50			Same as Q6		
Q51			Same as Q6		
Q52			Same as Q6		
Q53			Same as Q2		
Q54			Same as Q5		
Q55			Same as Q2		
R1	10010-182	13	1.8 k, ¼ W, 5%	AB	CB1825
R2	10011-101	6	100 ohm, ½ W, 5%	AB	EB1015
R3			Same as R2		
R4			Same as R1		
R5	10010-103	8	10 k, ¼ W, 5%	AB	CB1035
R6	10010-151	7	150 ohm, ¼ W, 5%	AB	CB1515
R7			Same as R1		
R8	10010-183	3	18 k, ¼ W, 5%	AB	CB1835
R9	10010-222	1	2.2 k, ¼ W, 5%	AB	CB2225
R10	10010-202	2	2 k, ¼ W, 5%	AB	CB2025
R11	10010-681	1	680 ohm, ¼ W, 5%	AB	CB6815
R12	10010-620	2	62 ohm, ¼ W, 5%	AB	CB6205
R13	10010-100	1	10 ohm, ¼ W, 5%	AB	CB1005
R20	10771-452	2	4.53 k, ½ W, 0.5%	ACI	RN70E
R21	10439-102	1	1 k, ¼ W, 5%	AB	SV1021
R22	10690-352	2	3.57 k, ½ W, 1%	IRC	RN60C
R23			Same as R22		
R24	10710-242	3	2.43 k, ¼ W, 1%	Corning	RN60D
R25	10010-153	3	15 k, ¼ W, 5%	AB	CB1535
R26	10771-841	1	845 ohm, ½ W, 0.5%	IRC	RN70E
R27	10010-102	7	1 k, ¼ W, 5%	AB	CB1025
R28	10771-931	1	931 ohm, ½ W, 0.5%	IRC	RN70E
R29	10010-271	6	270 ohm, ¼ W, 5%	AB	CB2715
R30			Same as R20		
R31	10010-331	2	330 ohm, ¼ W, 5%	AB	CB3315
R32	10439-251	1	Var. 250 ohm, ½ W, 10%	AB	SV2511
R33	10690-232	2	2.26 k, 1/8 W, 1%	IRC	RN60C
R34			Same as R33		
R35	10010-820	1	82 ohm, ¼ W, 5%	AB	CB8205
R36	10010-220	1	22 ohm, ¼ W, 5%	AB	CB2205
R37			Same as R6		
R38	10011-182	1	1.8 k, ½ W, 5%	AB	EB1825

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R39			Same as R6		
R40			Same as R29		
R41	10010-682	1	6.8 k, ¼ W, 5%	AB	CB6825
R42			Same as R1		
R43			Same as R5		
R50	10010-621	13	620 ohm, ¼ W, 5%	AB	CB6215
R51			Same as R50		
R52			Same as R50		
R53	10010-512	3	5.1 k, ¼ W, 5%	AB	CB5125
R54			Same as R53		
R55			Same as R53		
R56	10010-391	9	390 ohm, ¼ W, 5%	AB	CB3915
R57			Same as R56		
R58			Same as R56		
R59	10012-751	7	750 ohm, 1 W, 5%	AB	GB7515
R60	10439-501	9	Var. 500 ohm, ½ W, 10%	AB	SV5011
R61			Same as R59		
R62			Same as R60		
R63			Same as R59		
R64			Same as R60		
R65			Same as R59		
R66			Same as R60		
R67			Same as R59		
R68			Same as R60		
R69			Same as R59		
R70			Same as R60		
R71			Same as R59		
R72			Same as R60		
R73	10030-223	3	22 k, 1/8 W, 5%	AB	BB2235
R74			Same as R73		
R75			Same as R73		
R80			Same as R1		
R81			Same as R1		
R82			Same as R2		
R83			Same as R2		
R84			Same as R5		
R85			Same as R1		
R86			Same as R29		
R87			Same as R50		
R88	10010-123	2	1.2 k, ¼ W, 5%	AB	CB1235
R89	10010-201	8	200 ohm, ¼ W, 5%	AB	CB2015
R90	10010-332	3	3.3 k, ¼ W, 5%	AB	CB3325
R91	10010-561	1	560 ohm, ¼ W, 5%	AB	CB5615
R92			Same as R27		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R93			Same as R89		
R94			Same as R90		
R95			Same as R27		
R96	10010-302	4	3 k, ¼ W, 5%	AB	CB3025
R97	10010-203	1	20 k, ¼ W, 5%	AB	CB2035
R98			Same as R90		
R100			Same as R2		
R101	10010-221	1	220 ohm, ¼ W, 5%	AB	CB2215
R102			Same as R88		
R103			Same as R31		
R104			Same as R11		
R105			Same as R1		
R106	10010-821	4	820 ohm, ¼ W, 5%	AB	CB8215
R107			Same as R29		
R108			Same as R5		
R109			Same as R1		
R110			Same as R50		
R111			Same as R1		
R112			Same as R2		
R113	10010-101	3	100 ohm, ¼ W, 5%	AB	CB1015
R114			Same as R96		
R115	10010-131	1	130 ohm, ¼ W, 5%	AB	CB1315
R120	10010-272	2	2.7 k, ¼ W, 5%	AB	CB2725
R121			Same as R35		
R122	10011-242	1	2.4 k, ½ W, 5%	AB	EB2425
R123	10010-181	3	180 ohm, ¼ W, 5%	AB	CB1815
R124	10010-510	3	51 ohm, ¼ W, 5%	AB	CB5105
R125			Same as R27		
R126			Same as R6		
R127	10011-152	3	1.5 k, ½ W, 5%	AB	CB1525
R128	10010-470	1	47 ohm, ¼ W, 5%	AB	CB4705
R129	10010-270	1	27 ohm, ¼ W, 5%	AB	CB2705
R130			Same as R106		
R140			Same as R113		
R141			Same as R27		
R142			Same as R113		
R143			Same as R106		
R144			Same as R106		
R145			Same as R89		
R146	10012-152	1	1.5 k, 1 W, 5%	AB	GB1525
R147			Same as R27		
R148	10010-431	1	430 ohm, ¼ W, 5%	AB	CB4315
R149			Same as R6		
R150	10012-122	3	1.2 k, 1 W, 5%	AB	GB1225

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R151			Same as R8		
R152			Same as R12		
R153			Same as R50		
R154			Same as R89		
R160	10010-121	3	120 ohm, ¼ W, 5%	AB	CB1215
R161	10010-622	1	6.2 k, ¼ W, 5%	AB	CB6225
R162			Same as R50		
R163			Same as R1		
R164	10013-751	1	750 ohm, 2 W	AB	HB7515
R165			Same as R160		
R166			Same as R160		
R167			Same as R5		
R168			Same as R1		
R170			Same as R1		
R171			Same as R27		
R180			Same as R124		
R181			Same as R123		
R182			Same as R25		
R183			Same as R150		
R184			Same as R60		
R185			Same as R89		
R186			Same as R124		
R187			Same as R24		
R188			Same as R96		
R189			Same as R29		
R190			Same as R50		
R191			Same as R50		
R192			Same as R50		
R193	10010-393	6	3.9 k, ¼ W, 5%	AB	CB3935
R194			Same as R193		
R195			Same as R193		
R196			Same as R56		
R197			Same as R56		
R198			Same as R56		
R199	10721-122	12	1.2 k, ½ W, 5%	Liberty	C20
R200			Same as R199		
R201			Same as R199		
R202			Same as R199		
R203			Same as R199		
R204			Same as R199		
R205			Same as R25		
R210			Same as R120		
R211			Same as R6		
R212			Same as R123		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R214			Same as R150		
R215			Same as R60		
R216			Same as R89		
R217			Same as R6		
R218			Same as R24		
R219			Same as R96		
R220			Same as R29		
R230			Same as R50		
R231			Same as R50		
R232			Same as R50		
R233			Same as R193		
R234			Same as R193		
R235			Same as R193		
R236			Same as R56		
R237			Same as R56		
R238			Same as R56		
R239			Same as R199		
R240			Same as R199		
R241			Same as R199		
R242			Same as R199		
R243			Same as R199		
R244			Same as R199		
R250			Same as R127		
R251			Same as R89		
R252			Same as R5		
R253			Same as R5		
R254			Same as R89		
R255			Same as R127		
R256			Same as R5		
R257	10010-152	1	1.5 k, ¼ W, 5%	AB	CB1525
R258	10010-122	1	1.2 k, ¼ W, 5%	AB	CB1225
R259			Same as R8		
R260	10010-431	1	430 ohm, 1 W, 5%	AB	GB4315
R261			Same as R10		
Z1	12923-011	3	BCD-to-Decimal Decoder/-Driver	TI	SN7445N
Z2	12953-009	1	Dual Schmitt Trigger/-Triple Diff. Ampl.	Mot.	MC1035L
Z3	12903-006	2	Linear Transistor Array	RCA	CA3046
Z4			Same as Z1		
Z5			Same as Z3		
Z6			Same as Z1		
CR1	A22164-000	61	DP16-0	FT	DP16-0 (FD6282)
CR2			Same as CR1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR20			Same as CR1		
CR21	A22314-339	1	Zener, 3.3 V, 400 mW	Semcor	DP31-339 (1N746A)
CR22			Same as CR1		
CR24			Same as CR1		
CR49	22324-919	1	Zener, 9.1 V, 5%	Semcor	1N757A
CR50	A22324-100	1	Zener, 10.0 V, 1 W, 5%	JEDEC	1N4740A
CR51 thru CR61			Same as CR1		
CR62	12184-005	3	HPA5082-8830	HPA	HPA5082-8830
CR63			Same as CR62		
CR64			Same as CR62		
CR80 thru CR88			Same as CR1		
CR100			Same as CR1		
CR101			Same as CR1		
CR102			Same as CR1		
CR120			Same as CR1		
CR121			Same as CR1		
CR160			Same as CR1		
CR161			Same as CR1		
CR162			Same as CR1		
CR163			Same as CR1		
CR180	12144-003	3	1N955	Syl.	1N955
CR188	22314-479	2	Zener, 4.7 V, 400 mW	Mot.	DP31-479 (1N750A)
CR190	22324-150	2	Zener, 15 V, 1 W, 5%	Semcor	DP32-150 (1N4744A)
CR191 thru CR202			Same as CR1		
CR210			Same as CR180		
CR211			Same as CR180		
CR230			Same as CR190		
CR231 thru CR242			Same as CR1		
CR243			Same as CR188		
CR250			Same as CR1		
CR251			Same as CR1		
CR252			Same as CR1		

6.5 V_{UL}/V_{LL} CONTROL PCB ASSEMBLY (P/N37000-437)

C350	11241-223	4	0.022μF, 25 V	Sprague	HY525
C351			Same as C350		
C352	11247-103	4	0.01μF, 500 V	Erie	841000Z5V0-0103Z
C353	11492-685	4	6.8μF, 35 V, 20%	Sprague	196D685X0035KA1
C354			Same as C352		
C355			Same as C353		
C356	11491-226	1	22μF, 20 V, 20%	Sprague	196D226X0025LA3
C357			Same as C352		
C358			Same as C352		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C359			Same as C353		
C360			Same as C353		
C361			Same as C350		
C362			Same as C350		
Q349	12635-998	2	2N3641	FT	2N3641
Q350	12605-014	3	2N5087	Mot.	2N5087
Q351			Same as Q350		
Q352	12695-007	8	TZ82	Sprague	TZ82
Q353 thru Q359			Same as Q352		
Q360			Same as Q350		
Q361			Same as Q349		
Q362	12616-000	1	2N4918	Mot.	2N4918
Q363	12666-000	1	2N4921	Mot.	2N4921
R343	10439-502	2	Var. 5 k, ½ W, 10%	AB	SV5021
R344	10010-203	2	20 k, ¼ W, 5%	AB	CB2035
R345			Same as R344		
R346	10010-182	7	1.8 k, ¼ W, 5%	AB	CB1825
R347	10010-103	5	10 k, ¼ W, 5%	AB	CB1035
R348			Same as R343		
R349	10010-622	1	6.2 k, ¼ W, 5%	AB	CB6225
R350	10710-242	2	2.43 k, ¼ W, 1%	Corning	NA60
R351			Same as R350		
R352	10770-381	2	383 ohm, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R353			Same as R352		
R354			Same as R346		
R355			Same as R346		
R356	10010-101	4	100 ohm, ¼ W, 5%	AB	CB1015
R357	10010-132	4	1.3 k, ¼ W, 5%	AB	CB1325
R358			Same as R357		
R359			Same as R356		
R360			Same as R347		
R361			Same as R346		
R362			Same as R347		
R363			Same as R346		
R364	10010-433	4	43 k, ¼ W, 5%	AB	CB4335
R365			Same as R364		
R366	10010-123	4	12 k, ¼ W, 5%	AB	CB1235
R367			Same as R366		
R368			Same as R364		
R369			Same as R364		
R370			Same as R366		
R371			Same as R366		
R372	10690-913	2	90.9 k, 1/8 W, 1%	Electra	RN60C

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R373	10690-712	2	7.15 k, 1/8 W, 1%	Electra	RN60C
R374	10690-713	2	71.5 k, 1/8 W, 1%	Electra	RN60C
R375			Same as R374		
R376			Same as R373		
R377			Same as R372		
R378	10690-103	2	10 k, 1/8 W, 1%	Liberty	RN60C1002F
R379	10699-103	2	10.2 k, 1/8 W, 1%	Liberty	RN60C1022F
R380			Same as R379		
R381			Same as R378		
R382			Same as R347		
R383			Same as R347		
R384			Same as R357		
R385			Same as R357		
R386			Same as R346		
R387			Same as R346		
R388	10690-223	2	22.1 k, 1/8 W, 1%	Liberty	RN60C2262F
R389			Same as R388		
R390	10439-103	2	10 k, ½ W, 10%	AB	SV1031
R391			Same as R390		
R392			Same as R356		
R393			Same as R356		
R394	10721-202	2	2 k, ½ W, 5%	Liberty	RL20S202J
R395			Same as R394		
R396	10010-105	2	1 M, ¼ W, 5%	AB	CB1055
R397			Same as R396		
Z350	12903-000	4	Op Amp μA741C	FT	μA741C
Z351			Same as Z350		
Z352	12933-001	1	Dual 4-Channel Data Distributor	Mot.	MC9807P
Z353			Same as Z350		
Z354			Same as Z350		
CR348	22164-000	14	DP16-0	DP	
CR349			Same as CR348		
CR350	22314-919	8	Zener, 9.1 V, 400 mW	Semcor	1N757A
CR351			Same as CR350		
CR352			Same as CR350		
CR353			Same as CR350		
CR358			Same as CR348		
CR359			Same as CR348		
CR360			Same as CR350		
CR361			Same as CR350		
CR362			Same as CR350		
CR363			Same as CR350		
CR364			Same as CR348		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR365			Same as CR348		
CR366			Same as CR348		
CR367			Same as CR348		
CR368			Same as CR348		
CR369	22314-829	1	Zener, 8.2 V, 500 mW	Hamilton	1N959B (1N5237B)
CR370			Same as CR348		
CR372			Same as CR348		
CR373			Same as CR348		
CR374			Same as CR348		
CR375			Same as CR348		
6.6	**VARIABLE RISE/FALL POWER SUPPLY** (Model 154 only – P/N37001-429)				
C1	11247-103	9	0.01 μF, 500 V	Centralab	DD6-103
C2			Same as C1		
C20			Same as C1		
C40			Same as C1		
C60			Same as C1		
C61			Same as C1		
C62	11077-101	2	100 pF, 500 V, 5%	Arco	DM15E101J
C63	11077-330	2	33 pF, 500 V, 5%	Arco	DM15E330J
C64	11241-223	2	0.022 μF, 25 V	Centralab	2DDU60E223
C65	11492-685	4	6.8 μF, 35 V, 20%	Sprague	196D685X0035KA1
C80	11491-226	2	22 μF, 25 V, 20%	Sprague	196D226X0025LA3
C81			Same as C1		
C90			Same as C1		
C91			Same as C1		
C92			Same as C80		
C93			Same as C62		
C94			Same as C63		
C95			Same as C64		
C96			Same as C65		
C110	11512-105	2	1 μF, 35 V, 20%	Sprague	164D105X0035A2
C111			Same as C65		
C112			Same as C110		
C113			Same as C65		
CR80	22314-519	1	5.1 V, 400 mW	DP	1N751A
CR110	22324-919	2	9.1 V, 400 mW	JEDEC	1N4739A
CR111			Same as CR110		
Q61	12775-000	1	MS A14, NPN, 30 V	Mot.	MS A14
Q62	22635-011	2	DP6311	DP	DP6311
Q63	12635-998	1	2N3641, NPN, Si.	FT	2N3641
Q64	12605-014	1	2N5087, PNP, Si.	Mot.	2N5087

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q65	12605-002	1	2N2904A, PNP, Si.	Mot.	2N2904A
Q66	12605-017	1	MPS U52, PNP, Si.	Mot.	MPS U52
Q80			Same as Q62		
Q91	12785-000	1	MPS A65, 30 V, PNP	Mot.	MPS A65
Q92	12605-005	1	2N3638, NPN, Si.	FT	2N3638
Q93	12695-007	1	TZ82, NPN, Si.	Sprague	TZ82
Q94	12645-002	1	2N2219A, NPN, Si.	FT	2N2219A
R1	10690-103	12	10 k, 1/8 W, 1%	Liberty	RN60C1002F
R2			Same as R1		
R3			Same as R1		
R4			Same as R1		
R5	10441-253	2	25 k, ½ W, 10%	Beckman	89PR25K
R6	10690-104	1	100 k, 1/8 W, 1%	Liberty	RN60C1003F
R7	10441-502	3	5 k, ½ W, 10%	Beckman	89PR5K
R8	10690-825	1	8.25 k, 1/8 W, 1%	Electra	RN60C
R9			Same as R1		
R20			Same as R1		
R21	10690-102	3	1 k, 1/8 W, 1%	Liberty	RN60C1001F
R22	10710-502	4	4.99 k, ¼ W, 1%	Corning	NA60
R23	10441-103	1	10 k, ½ W, 10%	Beckman	89PR10K
R24			Same as R22		
R25	10441-501	4	500 ohm, ½ W, 10%	Beckman	89PR5K
R26			Same as R1		
R40			Same as R1		
R41			Same as R21		
R43			Same as R22		
R44			Same as R1		
R45			Same as R25		
R46			Same as R22		
R60	10710-681	1	681 ohm, ¼ W, 1%	Corning	NA60
R61	10010-360	2	36 ohm, ¼ W, 5%	AB	CB3605
R62	10011-222	3	2.2 k, ½ W, 5%	AB	EB2225
R63	10010-240	4	24 ohm, ¼ W, 5%	AB	CB2405
R64	10690-203	1	20 k, 1/8 W, 1%		RN60C
R65			Same as R25		
R66	10441-104	1	100 k, ½ W, 1%	Beckman	89PR100K
R67	10750-302	4	3.01 k, ¼ W, 1%	TI	CR-¼, RN60D
R68			Same as R63		
R69			Same as R1		
R70			Same as R7		
R71			Same as R67		
R72	10012-240	2	24 ohm, 1 W, 5%	AB	GB2405
R73	10012-510	2	51 ohm, 1 W, 5%	AB	GB5105
R80			Same as R63		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R81			Same as R63		
R82			Same as R62		
R90			Same as R5		
R91			Same as R1		
R92	10690-514	1	511 k, 1/8 W, 1%		RN60C
R93			Same as R21		
R94			Same as R62		
R95			Same as R61		
R96			Same as R25		
R97			Same as R67		
R98			Same as R1		
R99			Same as R67		
R100			Same as R7		
R101			Same as R72		
R102			Same as R73		
Z1	12903-000	7	Op Amp μA741C	FT	μA741C
Z2			Same as Z1		
Z20			Same as Z1		
Z40			Same as Z1		
Z60			Same as Z1		
Z61	12903-012	2	Op Amp LM308	National	LM308
Z80			Same as Z1		
Z81			Same as Z1		
Z91			Same as Z61		
6.7	VARIABLE RISE/FALL OUTPUT AMPLIFIER PCB ASSEMBLY (Model 154 only – P/N37000-954)				
C1	11512-226	2	22 μF, 35 V	Sprague	150D226X0035R2
C2			Same as C1		
C3	11240-474	3	0.47 μF, 10 V	Centralab	UK1D474
C4	11077-270	1	27 pF	Arco	DM15-270M
C5	11077-680	1	68 pF	Arco	DM15E680J
C6			Same as C3		
C8	11077-681	1	680 pF	Arco	DM15F681J
C9			Same as C3		
C11	11123-123	1	0.01 μF	IMB	ZP2B123J
C31	11241-223	15	0.022 μF, 22 V	Sprague	HY525
C32			Same as C31		
C33	11241-503	6	0.05 μF, 25 V	Erie	585SYS 503Z
C34	11242-104	1	0.1 μF, 75 V	Centralab	DDA104
C35			Same as C31		
C59	11077-391	2	390 pF	Arco	DM15F391J
C60			Same as C59		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C61			Same as C33		
C62	11372-103	4	0.01 μF, 50 V	Varadyne	17BX050S103M
C63			Same as C62		
C64			Same as C33		
C65	11491-476	2	47 μF, 15 V	Sprague	196D476X010LA1
C66			Same as C65		
C67	11491-336	2	33 μF, 15 V	Sprague	196D336X0025LA3
C68			Same as C67		
C69			Same as C31		
C70			Same as C33		
C71			Same as C62		
C72			Same as C62		
C73			Same as C33		
C81	11077-221	1	220 pF	Arco	DM15-221J
C82			Same as C31		
C83	11077-271	1	270 pF	Arco	DM15F271J
C84			Same as C31		
C85			Same as C31		
C86			Same as C31		
C87			Same as C31		
C88			Same as C31		
C89			Same as C33		
C101			Same as C31		
C102			Same as C31		
C103	11073-102	1	1000 pF, 100 V, 5%	Arco	DM15E102J
C104			Same as C31		
C105	11491-226	4	22 μF, 20 V	Sprague	196D226X0025LA3
C106			Same as C31		
C107			Same as C105		
C108			Same as C105		
C109			Same as C105		
C110			Same as C31		
J1	15050-102	3	Conn. 50 ohm min.	RVW	CON-HEX-51-052-0000
J2			Same as J1		
J3			Same as J1		
L61	14244-000	1	3.6 μH	Ferroxcube	VC200-20/4B
L62	14284-035	1	35 μH	Wilco	1035-15
R1	10010-182	9	1.8 k, ¼ W, 5%	AB	CB1825
R2			Same as R1		
R3	10010-103	3	10 k, ¼ W, 5%	AB	CB1035
R4			Same as R1		
R5			Same as R1		
R6			Same as R1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R7			Same as R1		
R8			Same as R3		
R9	10010-301	1	300 ohm, ¼ W, 5%	AB	CB3015
R10			Same as R1		
R11	10010-152	1	1.5 k, ¼ W, 5%	AB	CB1525
R12			Same as R3		
R13			Same as R1		
R14	10010-471	3	470 ohm, ¼ W, 5%	AB	CB4715
R15	10011-180	3	18 ohm, ½ W	AB	EB1805
R16	10010-222	3	2.2 k, ¼ W, 5%	AB	CB2225
R17	10030-390	1	39 ohm, 1/8 W, 5%	AB	BB3905
R18			Same as R14		
R19			Same as R15		
R20			Same as R16		
R21			Same as R14		
R22			Same as R15		
R23			Same as R16		
R31	10010-510	16	51 ohm, ¼ W, 5%	AB	CB5105
R32			Same as R31		
R33			Same as R31		
R34	10010-512	2	5.1 k, ¼ W, 5%	AB	CB5125
R35	10010-100	2	10 ohm, ¼ W, 5%	AB	CB1005
R36	10011-750	1	750 ohm, ½ W	AB	EB7505
R37			Same as R35		
R38			Same as R31		
R39			Same as R34		
R40			Same as R31		
R41			Same as R31		
R42			Same as R31		
R43			Same as R31		
R44	10010-682	2	6.8 k, ¼ W, 5%	AB	CB6825
R45			Same as R44		
R46			Same as R31		
R47			Same as R31		
R48	10010-201	2	200 ohm, ¼ W, 5%	AB	CB2015
R49			Same as R31		
R50			Same as R31		
R51			Same as R31		
R52			Same as R31		
R53			Same as R48		
R61	10010-102	6	1 k, ¼ W, 5%	AB	CB1025
R62	10010-391	4	390 ohm, ¼ W, 5%	AB	CB3915
R63	10010-330	4	33 ohm, ¼ W, 5%	AB	CB3305
R64			Same as R63		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R65			Same as R63		
R66			Same as R63		
R67			Same as R62		
R68			Same as R61		
R81	10012-202	2	2 k, 1 W	AB	GB2025
R82			Same as R61		
R83	10011-241	2	240 ohm, ½ W	AB	EB2415
R84			Same as R62		
R85	10010-151	4	150 ohm, ¼ W	AB	CB1515
R86			Same as R85		
R87	10010-111	2	110 ohm, ¼ W, 5%	AB	CB1115
R88			Same as R31		
R89			Same as R87		
R90			Same as R62		
R91			Same as R85		
R92			Same as R85		
R93			Same as R81		
R94			Same as R83		
R95			Same as R61		
R101	10010-101	2	100 ohm, ¼ W, 5%	AB	CB1015
R102	10013-120	2	12 ohm, 2 W	AB	HB1205
R103	10011-229	4	2.2 ohm, ½ W	AB	EB2298
R104			Same as R31		
R105			Same as R103		
R106			Same as R31		
R107			Same as R103		
R108			Same as R61		
R109			Same as R61		
R110			Same as R103		
R111			Same as R101		
R112			Same as R102		
Q1	12635-998	7	2N3641	FT	2N3641
Q2			Same as Q1		
Q3			Same as Q1		
Q4			Same as Q1		
Q5			Same as Q1		
Q6	22635-003	9	DP63-3	DP	DP63-3
Q7			Same as Q1		
Q8			Same as Q6		
Q9			Same as Q1		
Q10			Same as Q6		
Q11	22605-005	4	DP60-5	FT	DP60-5
Q12			Same as Q11		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q13	22645-000	5	DP64-0	SSS	DP64-0
Q14			Same as Q13		
Q15			Same as Q13		
Q16			Same as Q13		
Q17	12616-000	2	2N4918	Mot.	2N4918
Q22	12666-000	1	2N4921	Mot.	2N4921
Q23	12695-000	1	2N2270	RCA	2N699
Q24			Same as Q11		
Q25			Same as Q11		
Q26	12605-019	2	2N5583	Mot.	2N5583
Q27	12645-012	1	2N5109	RCA	2N5109
Q28			Same as Q6		
Q29			Same as Q6		
Q30	22595-000	1	DP59-0	FT	DP59-0 (S17988)
Q31			Same as Q6		
Q32			Same as Q6		
Q33			Same as Q17		
Q34			Same as Q13		
Q35			Same as Q26		
Q36			Same as Q22		
Q37			Same as Q6		
Q38			Same as Q6		
CR1	22164-000	26	DP16-0	FT	DP16-0 (FD6282)
CR2 thru CR14			Same as CR1		
CR31	22324-240	2	DP32-240, 24 V	Semcor	M4Z
CR32			Same as CR31		
CR33	22314-519	3	DP31-519, 5.1 V	Mot.	1N5231B
CR34	22324-100	2	DP32-100, 10 V	Semcor	1N4740A
CR35			Same as CR34		
CR59			Same as CR1		
CR60			Same as CR1		
CR61	22324-180	2	DP32-180, 18 V	Avnet	1N4746A
CR62	12184-005	3	HPA1003	HPA	1003
CR63			Same as CR62		
CR64			Same as CR62		
CR65			Same as CR61		
CR81	12154-046	2	5.1 V, Sharp Knee	Mot.	1N5231B
CR82			Same as CR33		
CR83			Same as CR1		
CR84			Same as CR1		
CR85			Same as CR1		
CR87	22314-339	4	DP31-339, 3.3 V	Semcor	1N746A
CR89			Same as CR87		
CR90			Same as CR1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR91			Same as CR1		
CR92			Same as CR1		
CR93			Same as CR33		
CR94			Same as CR81		
CR101			Same as CR1		
CR102			Same as CR1		
CR103			Same as CR87		
CR104			Same as CR87		
CR105			Same as CR1		
CR106			Same as CR1		
6.8	CIRCUIT BOARD ASSEMBLY–FIXED RISE/FALL OUTPUT AMPLIFIER (Model 153 only, P/N37000-919)				
C425	11491-226	9	22 μF, 25 V	Sprague	196D226X0025LA3
C426	11241-223	20	0.022 μF, 25 V	Sprague	HY525
C427			Same as C426		
C428	11249-689	1	6.8 pF, 1000 V	Sprague	10TCC-V68
C429			Same as C426		
C430	11512-226	4	22 μF, 35 V	Sprague	150D226X0035R2
C431			Same as C426		
C432			Same as C425		
C433			Same as C426		
C434			Same as C425		
C435			Same as C426		
C436			Same as C430		
C437			Same as C425		
C438			Same as C426		
C439			Same as C425		
C440			Same as C426		
C441			Same as C426		
C442			Same as C426		
C443			Same as C426		
C444	11077-509	1	5 pF, 500 V, 10%	Arco	DM15-050K
C445			Same as C426		
C446			Same as C426		
C447			Same as C430		
C448			Same as C426		
C449	11077-100	1	10 pF, 500 V	Arco	DM15E100J
C450			Same as C426		
C451			Same as C425		
C452			Same as C425		
C453			Same as C426		
C454			Same as C425		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C455			Same as C425		
C456			Same as C430		
C458			Same as C426		
C460			Same as C426		
C461			Same as C426		
J425	15050-102	3	BNC Conn. 50 ohm min.	Selectro	CON-HEX-51-052-0000
J426			Same as J425		
J427			Same as J425		
L425	14284-013	1	0.12 μH	Delevan	1025-96
L426	14284-011	1	0.33 μH	Delevan	1025-08
R423	10010-151	4	150 ohm, ¼ W, 5%	AB	CB1515
R424			Same as R423		
R425	10011-821	2	820 ohm, ½ W, 5%	AB	EB8215
R426	10010-510	4	51 ohm, ¼ W, 5%	AB	CB5105
R427			Same as R426		
R428	10010-330	4	33 ohm, ¼ W, 5%	AB	CB3305
R429			Same as R428		
R430			Same as R425		
R431	10010-103	2	10 k, ¼ W, 5%	AB	CB1035
R432	10010-121	2	120 ohm, ¼ W, 5%	AB	CB1215
R433	10011-681	1	680 ohm, ½ W, 5%	AB	EB6815
R434			Same as R431		
R435			Same as R432		
R436	10010-222	2	2.2 k, ¼ W, 5%	AB	CB2225
R437			Same as R436		
R438	10010-472	1	4.7 k, ¼ W, 5%	AB	CB4725
R439	10010-221	1	220 ohm, ¼ W, 5%	AB	CB2215
R440			Same as R428		
R441			Same as R428		
R442	10010-680	1	68 ohm, ¼ W, 5%	AB	CB6805
R443	10012-240	2	24 ohm, 1 W, 5%	AB	GB2405
R444	10012-510	2	51 ohm, 1 W, 5%	AB	GB5105
R445			Same as R444		
R446			Same as R443		
R447	10012-202	2	2 k, 1 W, 5%	AB	GB2025
R448			Same as R447		
R449	10010-301	4	300 ohm, ¼ W, 5%	AB	CB3015
R450			Same as R449		
R451			Same as R449		
R452			Same as R449		
R453	10010-391	2	390 ohm, ¼ W, 5%	AB	CB3915
R454			Same as R453		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R455	10011-241	2	240 ohm, ½ W, 5%	AB	EB2415
R456	10010-102	2	1 k, ¼ W, 5%	AB	CB1025
R457			Same as R423		
R458			Same as R423		
R459			Same as R426		
R460			Same as R426		
R461			Same as R456		
R462			Same as R455		
R463	10011-229	4	2.2 ohm, ¼ W, 5%	AB	EB2295
R464			Same as R463		
R465			Same as R463		
R466			Same as R463		
R467	10013-120	2	12 ohm, 2 W, 5%	AB	HB1205
R468	10010-101	2	100 ohm, ¼ W, 5%	AB	CB1015
R469			Same as R467		
R470	10011-511	1	510 ohm, ½ W, 5%	AB	EB5115
R471			Same as R468		
Q425	12635-998	1	2N3641	FT	2N3641
Q426	12605-012	4	2N4258	FT	2N4258
Q427			Same as Q426		
Q428	12605-005	1	2N3638	FT	2N3638
Q429			Same as Q426		
Q430			Same as Q426		
Q431	12645-012	2	2N5109	RCA	2N5109
Q432	12695-007	1	TZ82	Sprague	TZ82
Q433	12695-001	2	2N2270	RCA	2N2270
Q434			Same as Q431		
Q435	12666-000	2	2N4921	Mot.	2N4921
Q436	22605-008	4	DP608	Mot.	DP608 (SS2050)
Q437	22635-003	4	DP633	FT	DP633 (S15171)
Q438			Same as Q436		
Q439			Same as Q437		
Q440	22595-000	1	DP59-0	FT	DP59-0 (S17988)
Q441			Same as Q436		
Q442			Same as Q437		
Q443			Same as Q436		
Q444			Same as Q437		
Q445			Same as Q433		
Q446	22645-000	1	DP640		DP640
Q447	12605-019	1	2N5583	Mot.	2N5583
Q448			Same as Q435		
Q449	12616-000	1	2N4918	Mot.	2N4918
CR425	22314-130	1	DP31-130, 13 V	DP	
CR426	22164-000	18	DP16-0	SSS	DP16-0

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR427			Same as CR426		
CR431			Same as CR426		
CR432			Same as CR426		
CR433	12184-005	2	HPA5082-8830	HPA	HPA5082-8830
CR434			Same as CR426		
CR435			Same as CR426		
CR436			Same as CR426		
CR437	22314-519	2	DP31-519, 5.1 V	Mot.	1N5231B
CR438			Same as CR433		
CR439			Same as CR426		
CR440			Same as CR437		
CR441	22314-439	2	DP31-439, 4.3 V	West State	1N749A
CR442			Same as CR426		
CR443			Same as CR426		
CR444			Same as CR441		
CR445			Same as CR426		
CR446			Same as CR426		
CR447			Same as CR426		
CR448			Same as CR426		
CR449	12154-046	2	5.1 V, Sharp Knee	Mot.	1N5231B
CR450	22314-339	2	DP31-339, 3.3 V	Semcor	1N746A
CR451			Same as CR426		
CR452			Same as CR426		
CR454			Same as CR449		
CR455			Same as CR450		
CR456			Same as CR426		
CR457			Same as CR426		
6.9	PCB ASSEMBLY 150 POWER SUPPLIES and REGULATORS (P/N37000-913)				
C501	11168-158	2	15000 μF, 50 V	STM	23C50T5152
C502	11242-104	4	0.1 μF, 75 V	Centralab	DDA104
C503	B11162-107	3	100 μF, 15 V	Nashville	20-500BP100-35S85
C504	11491-475	1	4.7 μF, 20 V	Sprague	196D475X0020EB
C521			Same as C501		
C522			Same as C502		
C523			Same as C503		
C531	11151-358	2	35000 μF, 25 V	STM	23C25TA352
C532			Same as C531		
C533			Same as C502		
C534			Same as C502		
C535	B11169-107	1	100 μF, 15 V	Nashville	12-437BD100-15S65
C536			Same as C503		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C537	11247-103	1	0.01 μF, 500 V	Erie	841000Z5VO-0103
C538	11491-476	1	47 μF, 20 V	Sprague	196D476X020LA1
R501	10010-562	3	5.6 k, ¼ W, 5%	AB	CB5625
R502	10010-201	1	200 ohm, ¼ W, 5%	AB	CB2015
R503			Same as R501		
R504	10264-109	4	1 ohm, 3 W, 5%	Sprague	450G1R05
R505	10010-121	2	120 ohm, ¼ W, 5%	AB	CB1215
R506	10010-332	2	3.3 k, ¼ W, 5%	AB	CB3325
R507	10010-820	5	82 ohm, ¼ W, 5%	AB	CB8205
R508	10721-222	1	2.2 k, ½ W, 5%	Liberty	RL20S222J
R509	10710-162	1	1.62 k, ¼ W, 1%	Corning	NA60
R510	10439-251	1	250 ohm, ½ W, 10%	AB	SV2511
R511	10690-821	1	825 ohm, 1/8 W, 1%	Electra	RN60C
R521			Same as R501		
R522			Same as R504		
R523			Same as R505		
R524			Same as R506		
R525			Same as R507		
R526	10690-103	4	10 k, 1/8 W, 1%	TI	RN60C1002F
R527	10439-102	1	1 k, ½ W, ±10%	AB	SV1021
R528			Same as R526		
R530			Same as R504		
R531			Same as R504		
R532	10010-471	1	470 ohm, ¼ W, 5%	AB	CB4715
R533	10010-162	1	1.6 k, ¼ W, 5%	AB	CB1625
R534	10264-279	1	2.7 ohm, 3 W, ±5%	Ohmite	4341
R535	10010-511	1	510 ohm, ¼ W, 5%	AB	CB5115
R536	10010-152	1	1.5 k, ¼ W, 5%	AB	CB1525
R537			Same as R507		
R538			Same as R507		
R539			Same as R526		
R540	10710-252	1	2.49 k, ¼ W, 1%	Corning	RN60D NA60
R541			Same as R526		
R542	10710-202	1	2 k, ¼ W, 1%	Corning	RN60D NA60
R543	10011-629	1	6.2 ohm, ½ W, 5%	AB	EB6295
R544	10010-301	1	300 ohm, ¼ W, 5%	AB	CB3015
R545	10010-122	1	1.2 k, ¼ W, 5%	AB	CB1225
R546			Same as R507		
R547	10690-113	1	11.5 k, 1/8 W, ±1%	Liberty	RN60C1152F
R548	10710-102	1	1 k, ¼ W, 1%	Corning	RN60D NA60
Q501	12605-005	1	2N3638	FT	2N3638
Q502	12675-009	3	2N3055	RCA	2N3055
Q503	12695-001	4	2N2270	RCA	2N2270
Q504	12695-007	5	TZ82	Sprague	TZ82

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q505			Same as Q502		
Q506			Same as Q503		
Q507			Same as Q504		
Q508			Same as Q502		
Q509			Same as Q503		
Q510			Same as Q504		
Q511			Same as Q503		
Q512			Same as Q504		
Q513			Same as Q504		
Q514	12616-000	1	2N4918	Mot.	2N4918
Q515	22595-000	1	DP59-0		DP59-0
Q516	12605-014	1	2N5087	Mot.	2N5087
Z501	12903-000	5	IC μA741C	FT	μA741C
Z502			Same as Z501		
Z503			Same as Z501		
Z504			Same as Z501		
Z505			Same as Z501		
CR501	12374-001	12	IRC 20A1	IRC	20A1
CR502			Same as CR501		
CR503			Same as CR501		
CR504			Same as CR501		
CR505	22314-479	1	DP31-479 (1N750A)	Mot.	1N750A
CR506	22314-300	1	DP31-300	DP	
CR507	22314-100	4	DP31-100 (1N758A)	Semcor	1N758A (GA4Z)
CR508	12154-201	1	1N936	Mot.	1N936
CR521			Same as CR501		
CR522			Same as CR501		
CR523			Same as CR501		
CR524			Same as CR501		
CR525			Same as CR507		
CR526			Same as CR507		
CR527			Same as CR507		
CR531			Same as CR501		
CR532			Same as CR501		
CR533			Same as CR501		
CR534			Same as CR501		

6.10 PCB ASSEMBLY—LINEAR D/A CONVERTER (Model 153/154—1 Positive True, P/N37001-145, Model 153/154—1 Ground True, P/N37001-144, Model 153/154—3 Positive True and Ground True, P/N37001-146)

C1	11241-223	6	0.022 μF, 25 V	Sprague	HY525
C2			Same as C1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C3			Same as C1		
C4			Same as C1		
C5			Same as C1		
C6			Same as C1		
C7	11492-685	1	6.8 μF, 35 V	Sprague	196D685X0035KA1
C8	11491-226	2	22 μF, 20 V	Sprague	196D226X0025LA3
C9			Same as C8		
R1	10010-182	16	1.8 k, ¼ W, 5%	AB	CB1825
R2	10010-132	12	1.3 k, ¼ W, 5%	AB	CB1325
R3	10770-233	1	23.7 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R4			Same as R1		
R5			Same as R2		
R6	10770-123	1	12.1 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R7			Same as R1		
R8			Same as R2		
R9	10770-592	1	5.8 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R10			Same as R1		
R11			Same as R2		
R12	10700-302	1	3.01 k, 1/8 W, 0.5%	Ultex	RN65C
R13			Same as R1		
R14			Same as R2		
R15	10710-234	1	237 k, 1/8 W, 1%	Corning	NA60
R16			Same as R1		
R17			Same as R2		
R18	10710-124	1	121 k, 1/8 W, 1%	Corning	NA60
R19			Same as R1		
R20			Same as R2		
R21	10710-593	1	59 k, 1/8 W, 1%	Corning	NA60
R22			Same as R1		
R23			Same as R2		
R24	10710-303	1	30.1 k, 1/8 W, 0.5%	Corning	NA60
R25			Same as R1		
R26			Same as R2		
R27	10010-245	1	2.4 M, ¼ W, 5%	AB	CB2455
R28			Same as R1		
R29			Same as R2		
R30	10010-135	1	1.3 M, ¼ W, 5%	AB	CB1355
R31			Same as R1		
R32			Same as R2		
R33	10010-624	1	620 k, ¼ W, 5%	AB	CB6245
R34			Same as R1		
R35			Same as R2		
R36	10010-304	1	300 k, ¼ W, 5%	AB	CB3045

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R37			Same as R1		
R38			Same as R1		
R39			Same as R1		
R40			Same as R1		
Q1	12635-998	12	2N3641	FT	2N3641
Q2 thru Q12			Same as Q1		
Z4	12922-012	4	IC 4 Bit Bistable Latch (serial to parallel only)	TI	SN7475N
Z5			Same as Z4		
Z6			Same as Z4		
Z7			Same as Z4		
CR1	A22164-000	13	DP16-0/1N3600	FT	DP16-0 (FD6282
CR2 thru CR13			Same as CR1		
Z1	12922-010	3	IC Hex Inverter Buffer Driver (positive true parallel only)	TI	SN7416N
Z2			Same as Z1		
Z3			Same as Z1		
Z1	12922-011	3	IC Hex Buffer/Driver (ground true parallel only)	TI	SN7417N
Z2			Same as Z1		
Z3			Same as Z1		
6.11	PCB ASSEMBLY–HYPERBOLIC D/A CONVERTER (P/N37001-147, P/N37001-148, P/N37001-149)				
C1	11241-223	6	0.022 μF, 25 V	Sprague	HY525
C2			Same as C1		
C3			Same as C1		
C4			Same as C1		
C5			Same as C1		
C6			Same as C1		
C7	11491-475	1	4.7 μF, 20 V	Sprague	196D475X0020EB
C8	11247-103	1	0.01 μF, 500 V	Erie	841000Z5VO-0103
C9	11492-685	2	6.8 μF, 35 V	Sprague	196D685X0035KA1
C10	11491-226	3	22 μF, 20 V	Sprague	196D226X0025LA3
C11			Same as C9		
C12			Same as C10		
C13			Same as C10		
R1	10010-102	12	1 k, ¼ W, 5%	AB	CB1025
R2	10010-512	12	5.1 k, ¼ W, 5%	AB	CB5125
R3	10010-243	12	24 k, ¼ W, 5%	AB	CB2435
R4	10770-103	1	10.2 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R5	10010-362	16	3.6 k, ¼ W, 5%	AB	CB3625
R6			Same as R1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R7			Same as R2		
R8			Same as R3		
R9	10770-512	1	5.1 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R10			Same as R5		
R11			Same as R1		
R12			Same as R2		
R13			Same as R3		
R14	10770-252	1	2.55 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R15			Same as R5		
R16			Same as R1		
R17			Same as R2		
R18			Same as R3		
R19	10770-132	1	1.275 k, 1/8 W, 0.5%	ACI	EE-1/8 (RN60C)
R20			Same as R5		
R21			Same as R1		
R22			Same as R2		
R23			Same as R3		
R24	10699-104	1	102 k, 1/8 W, 1%	Liberty	RN60C1023F
R25			Same as R5		
R26			Same as R1		
R27			Same as R2		
R28			Same as R3		
R29	10690-513	1	51.1 k, 1/8 W, 1%	Liberty	RN60C5112F
R30			Same as R5		
R31			Same as R1		
R32			Same as R2		
R33			Same as R3		
R34	10690-253	1	25.5 k, 1/8 W, 1%	Liberty	RN60C2552F
R35			Same as R5		
R36			Same as R1		
R37			Same as R2		
R38			Same as R3		
R39	10690-133	1	12.7 k, 1/8 W, 1%	Liberty	RN60C1272F
R40			Same as R5		
R41			Same as R1		
R42			Same as R2		
R43			Same as R3		
R44	10010-105	1	1 M, ¼ W, 5%	AB	CB1055
R45			Same as R5		
R46			Same as R1		
R47			Same as R2		
R48			Same as R3		
R49	10010-514	1	510 k, ¼ W, 5%	AB	CB5145
R50			Same as R5		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R51			Same as R1		
R52			Same as R2		
R53			Same as R3		
R54	10690-254	1	255 k, 1/8 W, 1%	Liberty	RN60C2552F
R55			Same as R5		
R56			Same as R1		
R57			Same as R2		
R58			Same as R3		
R59	10010-134	1	130 k, ¼ W, 5%	AB	CB1345
R60			Same as R5		
R61			Same as R5		
R62			Same as R5		
R63			Same as R5		
R64			Same as R5		
R65	10441-254	1	250 k, ½ W, 10%	GS Marshall	89DR250K
R66	10690-104	1	100 k, 1/8 W, 1%	Liberty	RN60C1003F
R67	10690-102	1	1 k, 1/8 W, 1%	Liberty	RN60C1001F
R68	10780-502	1	5 k, 1/8 W, 0.1%	ACI	EE-1/8 (RN60C)
R69	10010-621	1	620 ohm, ¼ W, 5%	AB	CB6215
R70	10010-301	1	300 ohm, ¼ W, 5%	AB	CB3015
R71	10690-182	1	1.82 k, 1/8 W, 1%	Liberty	RN60C
R72	10441-501	1	500 ohm, ½ W, 10%	Beckman	79PR500
R73	10010-101	1	100 ohm, ¼ W, 5%	AB	CB1015
R74	10690-153	1	15 k, 1/8 W, 1%	Liberty	RN60C1502F
Q1	12635-998	12	2N3641	FT	2N3641
Q2	12605-014	14	2N5087	Mot.	2N5087
Q3			Same as Q1		
Q4			Same as Q2		
Q5			Same as Q1		
Q6			Same as Q2		
Q7			Same as Q1		
Q8			Same as Q2		
Q9			Same as Q1		
Q10			Same as Q2		
Q11			Same as Q1		
Q12			Same as Q2		
Q13			Same as Q1		
Q14			Same as Q2		
Q15			Same as Q1		
Q16			Same as Q2		
Q17			Same as Q1		
Q18			Same as Q2		
Q19			Same as Q1		
Q20			Same as Q2		

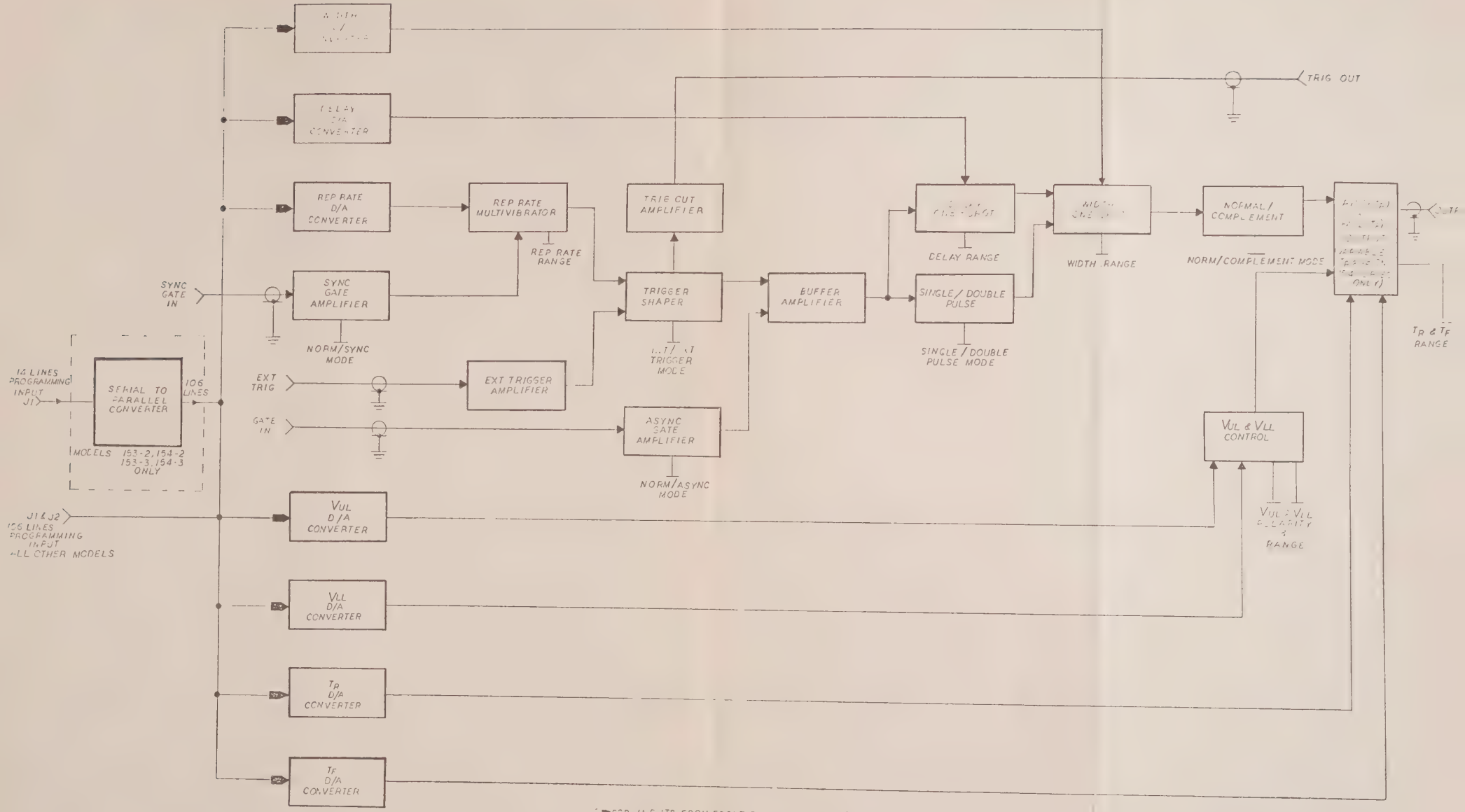
REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Q21			Same as Q1		
Q22			Same as Q2		
Q23			Same as Q1		
Q24			Same as Q2		
Q25	12695-007	1	TZ82	Sprague	TZ82
Q26			Same as Q2		
Q27	12775-000	1	MPS A14	Sprague	TD401
Q28			Same as Q2		
Z4	12922-012	4	8 and 4 Bit Bi-Stable Latch (serial to parallel only)	TI	SN7475N
Z5			Same as Z4		
Z6			Same as Z4		
Z7			Same as Z4		
CR1	22164-000	5	DP16-0/1N3600	FT	DP16-0 (FD6282)
CR2			Same as CR1		
CR3			Same as CR1		
CR4			Same as CR1		
CR5			Same as CR1		
Z1	12922-010	3	Hex Inverter Buffer/Driver (ground true parallel only)	TI	SN7416N
Z2			Same as Z1		
Z3			Same as Z1		
Z1	12922-011	3	Hex Buffer/Driver (positive true parallel only)	TI	SN7417N
Z2			Same as Z1		
Z3			Same as Z1		
6.12	HYPERBOLIC CONDUCTANCE D/A CONVERTER (P/N37001-430, P/N37001-431, P/N37001-432)				
C1	11491-226	2	22 μF, 25 V, 20%	Sprague	196D226X0025LA3
C3	11241-223	4	0.022 μF, 25 V	Centralab	2DDU60E223M
C4			Same as C3		
C8			Same as C3		
C9			Same as C3		
C10			Same as C1		
R1	10010-222	13	2.2 k, ¼ W, 5%	AB	CB2225
R2			Same as R1		
R3	10780-103	8	51 k, 1/8 W, 0.1%	ACI	EE-1/8 (RN60C)
R4			Same as R1		
R5			Same as R1		
R6	10780-512	1	5.1 k, 1/8 W, 0.1%	ACI	EE-1/8 (RN60C)
R7	10010-136	1	13 M, ¼ W, 5%	AB	CB1365
R8			Same as R1		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R9			Same as R1		
R10	10780-252	1	2.550 k, 1/8 W, 0.1%	ACI	EE-1/8, RN60C
R11	10010-135	1	1.3 M, ¼ W, 5%	AB	CB1355
R12			Same as R1		
R13			Same as R1		
R14	10780-132	1	1.275 k, 1/8 W, 0.1%	ACI	EE-1/8, RN60C
R15	10010-824	1	820 k, ¼ W, 5%	AB	CB8245
R16			Same as R1		
R17	10780-104	1	102 k, 1/8 W, 0.1%	ACI	EE-1/8, RN60C
R18			Same as R1		
R19			Same as R1		
R20			Same as R1		
R21			Same as R3		
R22			Same as R1		
R23	10780-253	1	23.153 k, 1/8 W, 0.1%	ACI	EE-1/8, RN60C
R24			Same as R1		
R25	10010-222	14	2.2 k, ¼ W, 5%	AB	CB2225
R26			Same as R25		
R27	10780-133	1	12.75 k, 1/8 W, 0.1%	ACI	EE-1/8, RN60C
R28			Same as R25		
R29	10690-105	1	1 M, 1/8 W, 1%		RN60C
R30			Same as R25		
R31			Same as R25		
R32			Same as R25		
R33	10690-514	1	511 k, 1/8 W, 1%		RN60C
R34			Same as R25		
R35	10690-254	1	255 k, 1/8 W, 1%		RN60C
R36			Same as R25		
R37			Same as R25		
R38			Same as R25		
R39	10690-134	1	127 k, 1/8 W, 1%		RN60C
R40			Same as R25		
R41			Same as R25		
R42			Same as R25		
R43			Same as R25		
Q1	22635-011	12	DP63-11	DP	DP63-11
Q2 thru Q12			Same as Q1		
Z1	12922-011	3	Hex Buffer/Driver (positive true parallel only)	TI	SN7417N
Z2			Same as Z1		
Z3			Same as Z1		
Z8	12922-010	2	Hex Inverter Buffer/Driver (ground true parallel only)	TI	SN7416N
Z9			Same as Z8		

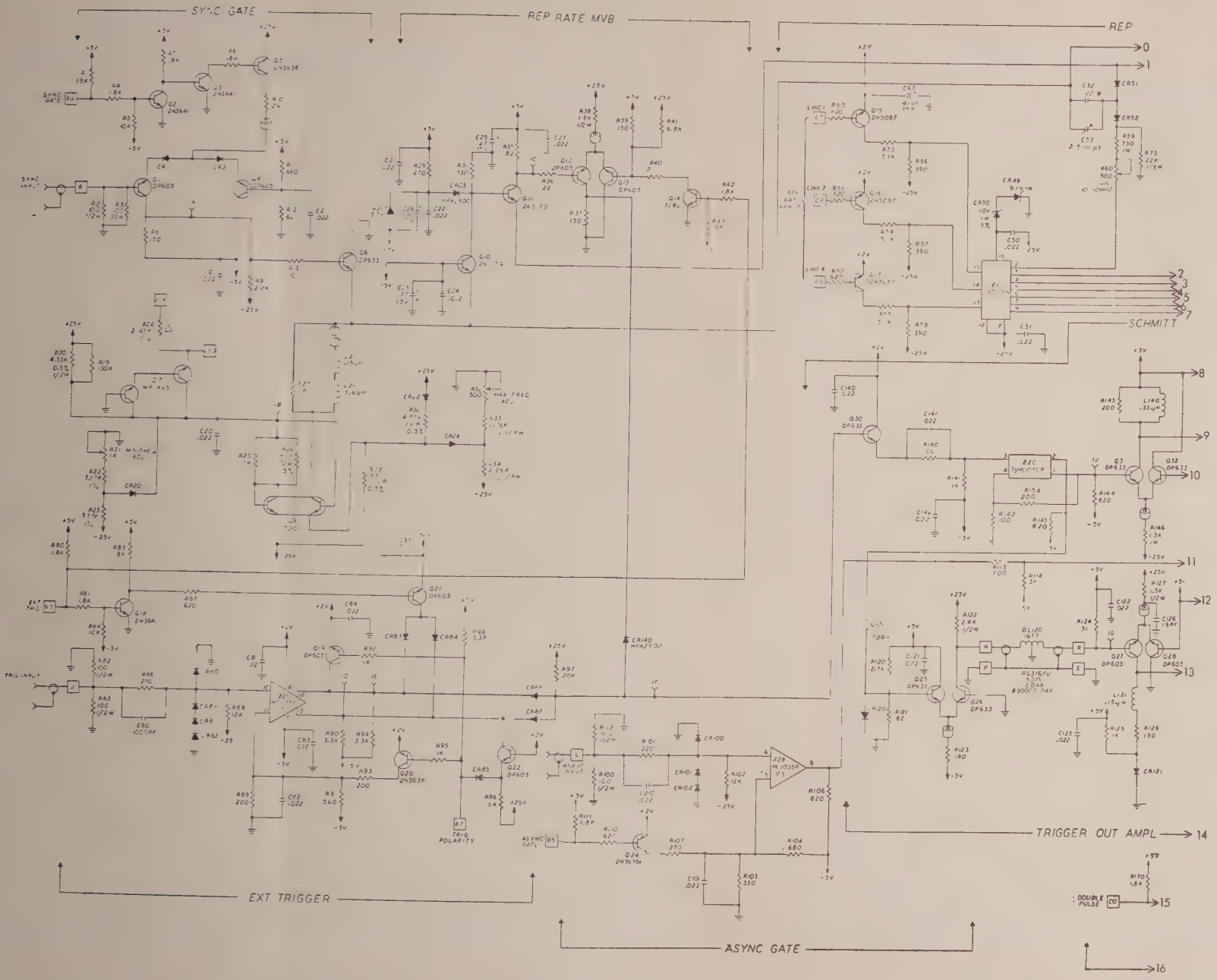
6.13 PCB ASSEMBLY SERIAL to PARALLEL CONVERTER (Model 153/154—3 Positive True, P/N37001-151 — Model 153/154—3 Ground True, P/N37001-150)

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C1	11241-223	10	0.022 μF, 20 V	Sprague	HY525
C2			Same as C1		
C3			Same as C1		
C4			Same as C1		
C5			Same as C1		
C6	11077-271	2	270 pF, 500 V	Arco	DM15F271J
C7			Same as C6		
C8			Same as C1		
C9			Same as C1		
C10			Same as C1		
C11			Same as C1		
C12			Same as C1		
C13	11491-226	2	22 μF, 25 V	Sprague	196D226X0025LA3
C14			Same as C13		
R1	10010-182	25	1.8 k, ¼ W, 5%	AB	CB1825
R2 thru R8			Same as R1		
R9	10010-102	6	1 k, ¼ W, 5%	AB	CB1025
R10			Same as R9		
R11			Same as R9		
R12			Same as R9		
R13			Same as R9		
R14	10010-272	2	2.7 k, ¼ W, 5%	AB	CB2725
R15			Same as R14		
R16			Same as R9		
R17 thru R33			Same as R1		
Z1	12922-010	7	IC Hex Inverter Buffer/Driver (positive true only)	TI	SN7416N
Z2			Same as Z1		
Z3			Same as Z1		
Z4			Same as Z1		
Z5	12922-009	2	IC Quad 2 Input NOR Gate	TI	SN7402N
Z6			Same as Z5		
Z7	12922-013	2	IC BCD Decimal Decoder/Driver	TI	SN74145
Z8			Same as Z7		
Z9			Same as Z1		
Z10			Same as Z1		
Z11			Same as Z1		
CR1	12144-003	2	1N995	Syl.	1N995
CR2			Same as CR1		

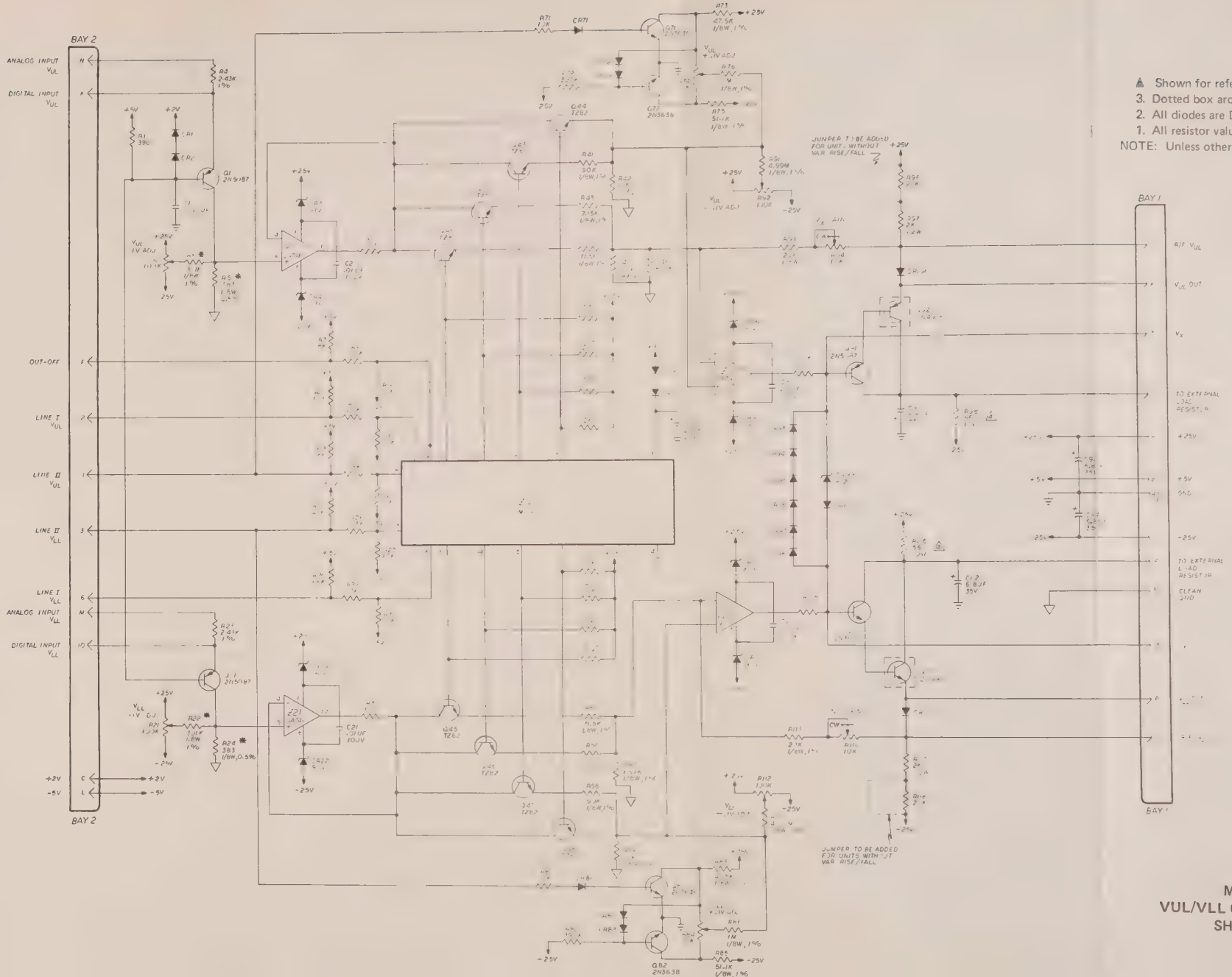
REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
Z1	12922-011	4	IC Hex Buffer Driver (ground true only)	TI	SN7417N
Z2			Same as Z1		
Z3			Same as Z1		
Z4			Same as Z1		
6.14	**BACK PANEL ASSEMBLY – 150 SERIES** (P/N37000-952)				
J501	A15010-044	1	Conn. AC In	Amphenol	160-5N
J1	15050-098	2	Conn.	Winchester	MRAC75-5J6
J2			Same as J1		
B501	13350-056	1	Fan	IMC	WS2107F
F501	15470-003	1	Fuse, 3A, 110 V	Bussman	AGC3
S502	B15310-003	1	Switch, Slide	CW	G626
T501	C24010-032	1	Xfmr., Power		
	A15470-022	1	Fuse Holder	Bussman	HKP
	15050-000	5	BNC Conn.	Amphenol	667-2-31-22


TRIG OUT
DELAY D/A CONVERTER
REP RATE D/A CONVERTER
REP RATE MULTIVIBRATOR
REP RATE RANGE
TRIG OUT AMPLIFIER
DELAY RANGE
WIDTH RANGE
NORMAL/ COMPLEMENT
NORM/COMPLEMENT MODE
SYNC GATE IN
SYNC GATE AMPLIFIER
NORM/SYNC MODE
TRIGGER SHAPER
INT/EXT TRIGGER MODE
BUFFER AMPLIFIER
SINGLE/DOUBLE PULSE
SINGLE/DOUBLE PULSE MODE
TP & TF RANGE
14 LINES PROGRAMMING INPUT J1
SERIAL TO PARALLEL CONVERTER
106 LINES
MODELS 153-2, 154-2 153-3, 154-3 ONLY
EXT TRIG
EXT TRIGGER AMPLIFIER
GATE IN
ASYNC GATE AMPLIFIER
NORM/ASYNC MODE
VUL & VLL CONTROL
VUL & VLL POLARITY & RANGE
J1 & J2 106 LINES PROGRAMMING INPUT ALL OTHER MODELS
VUL D/A CONVERTER
VLL D/A CONVERTER
TP D/A CONVERTER
TF D/A CONVERTER
ECD INPUTS FROM FRONT PANEL CONTROLS (MODEL 153-1, 154-1, 153-3, 154-3) OR REMOTE PROGRAMMING SOURCE (MODEL 153, 153-1, 154, 154-1, 153-2, 154-2)
ECD INPUTS FOR MODE & RANGE SELECTION FROM FRONT PANEL CONTROLS (MODEL 153-1, 154-1, 153-3, 154-3 OR REMOTE PROGRAMMING SOURCES (MODEL (153, 153-1, 154, 154-1, 153-2, 154-2)
NOTE: UNLESS OTHERWISE SPECIFIED

MODEL 153/154–1 and 3
BLOCK DIAGRAM #41000–230
REV A



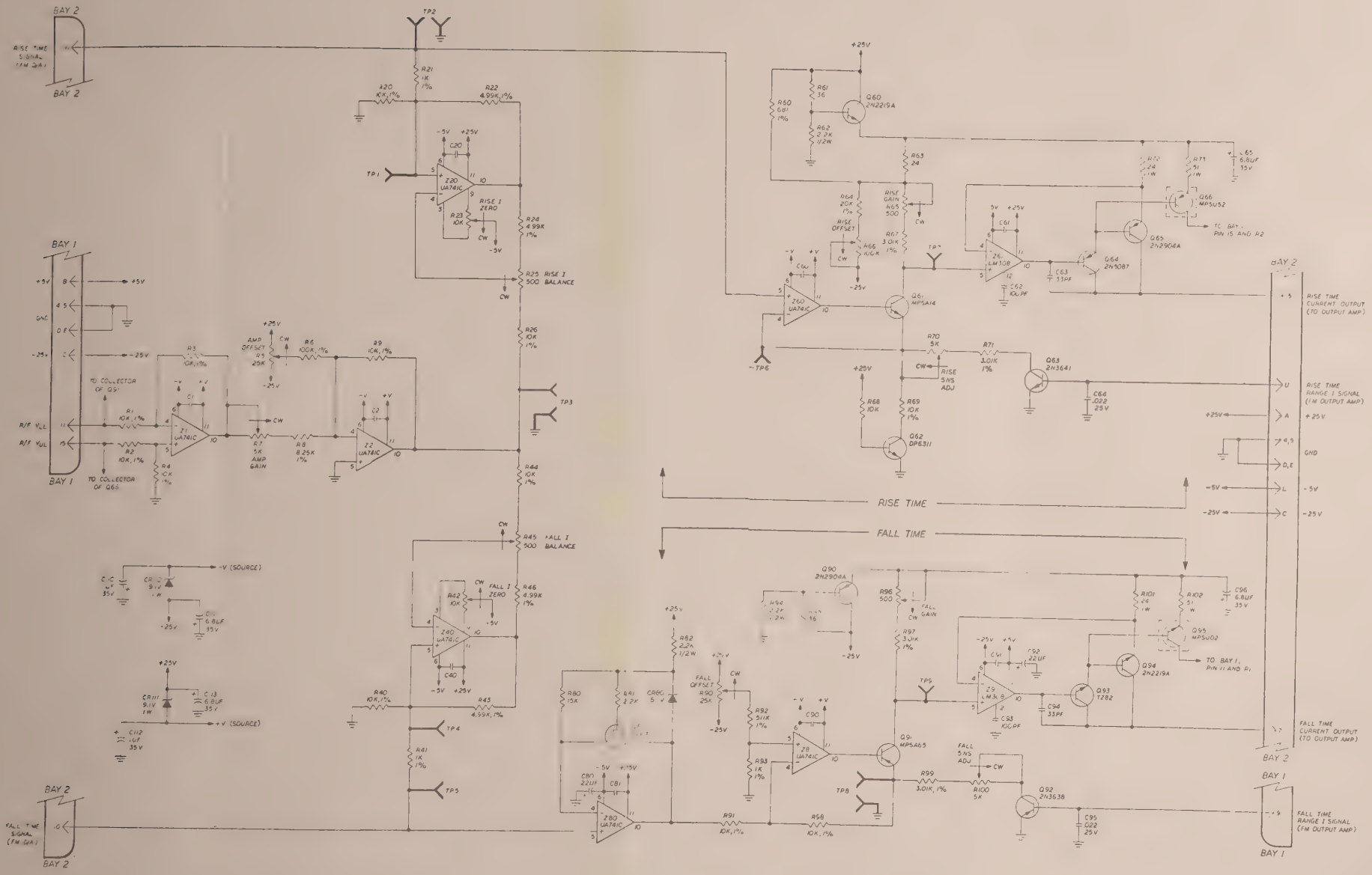
MODEL 153/154–1 and 3
FRONT END BOARD SCHEMATIC
SHEET 1 OF 2 #40000–421
REV E



▲ Shown for reference only.
3. Dotted box around transistor indicates heatsink
2. All diodes are DP16-0
1. All resistor values are in ohms, 1/4W, 5%
NOTE: Unless otherwise specified

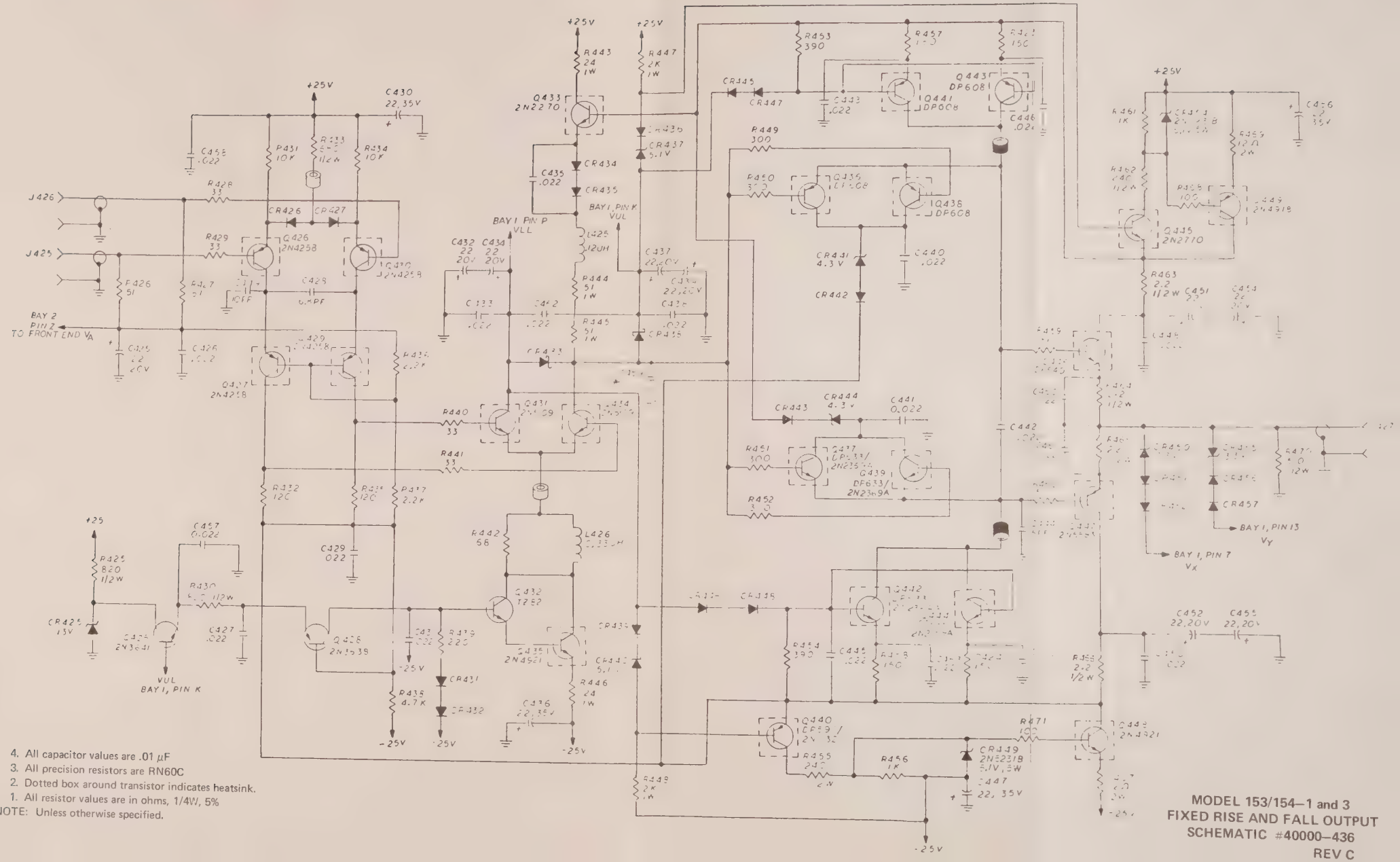
MODEL 153/154–1 and 3
VUL/VLL CONTROL CIRCUIT SCHEMATIC
SHEET 1 OF 1 #40000–558

REV A



4 ALL CAPACITOR VALUES ARE .01UF
3 ALL PRECISION RESISTORS ARE RN60C
2 DOTTED BOX AROUND TRANSISTOR INDICATES HEATSINK.

MODEL 153/154–1 and 3
VAR RISE AND FALL POWER SUPPLY II
SCHEMATIC #40000–551



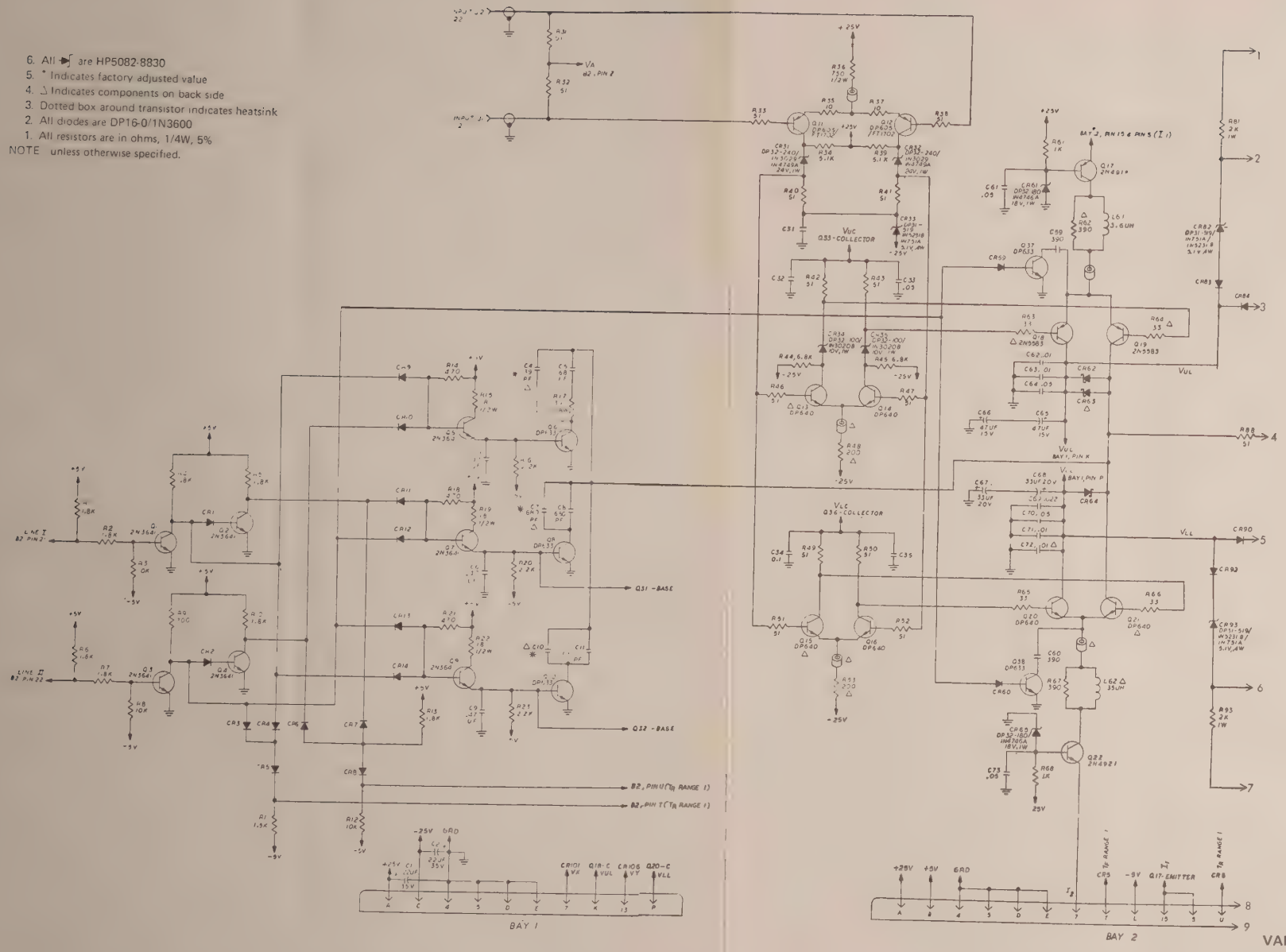
4. All capacitor values are .01 μF
3. All precision resistors are RN60C
2. Dotted box around transistor indicates heatsink.
1. All resistor values are in ohms, 1/4W, 5%

NOTE: Unless otherwise specified.

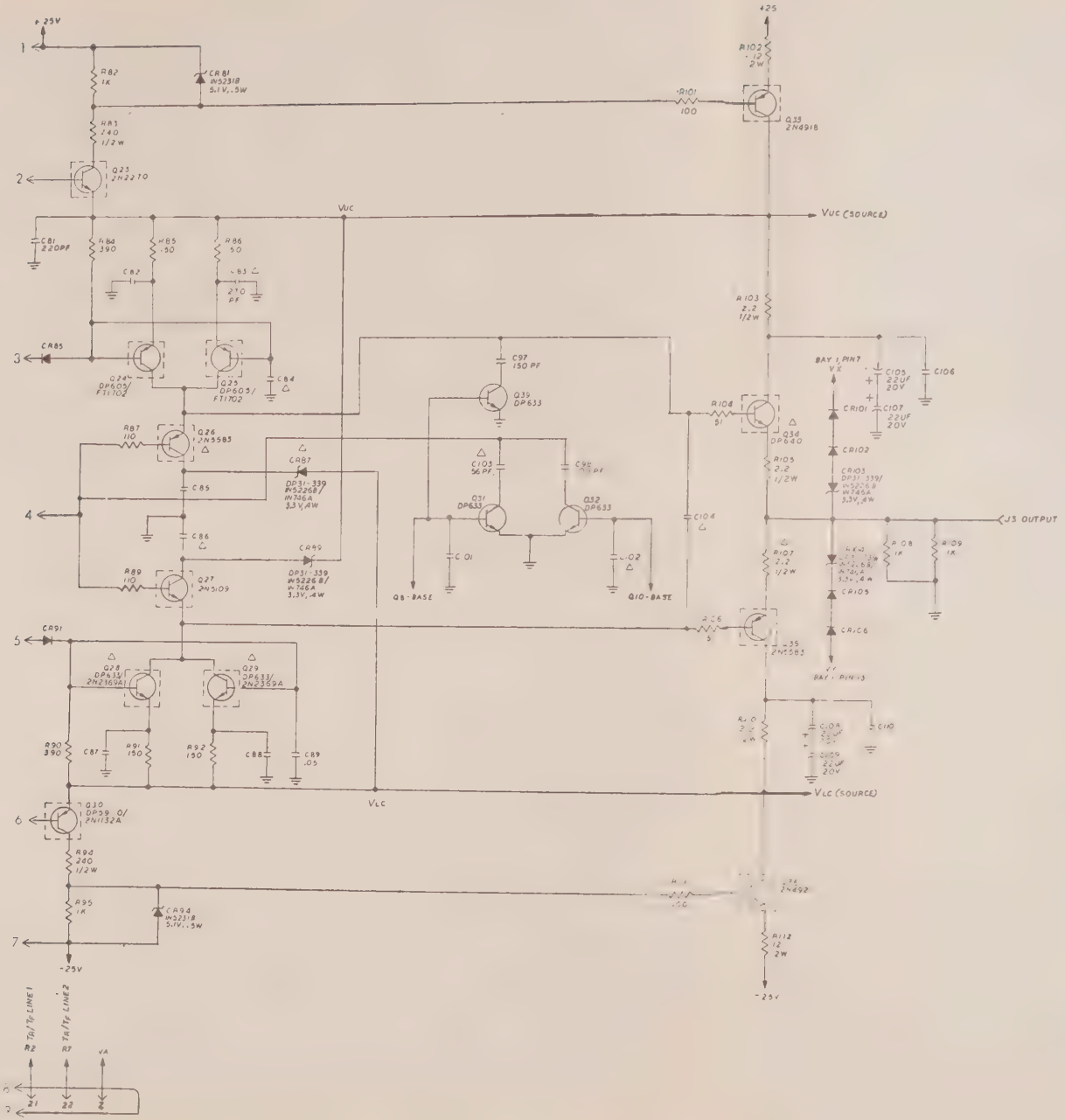
MODEL 153/154—1 and 3
FIXED RISE AND FALL OUTPUT
SCHEMATIC #40000—436
REV C

6. All ▶| are HP5082-8830
5. * Indicates factory adjusted value
4. Δ Indicates components on back side
3. Dotted box around transistor indicates heatsink
2. All diodes are DP16-0/1N3600
1. All resistors are in ohms, 1/4W, 5%

NOTE unless otherwise specified.

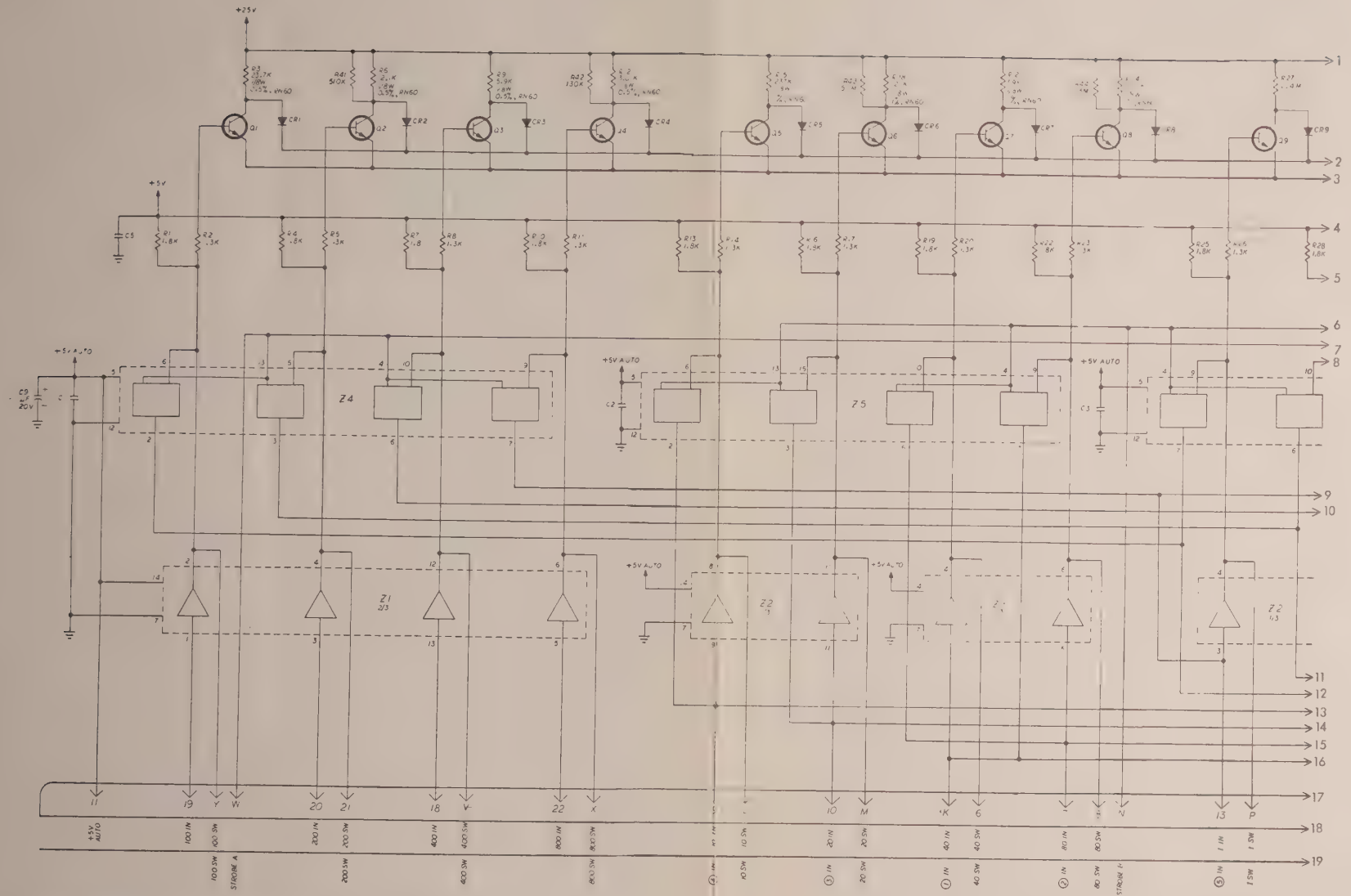


MODEL 153/154—1 and 3
VAR RISE AND FALL OUTPUT AMPLIFIER
SCHEMATIC SHEET 1 OF 2 #40000—438
REV E



MODEL 153/154–1 and 3
VAR RISE AND FALL OUTPUT AMPLIFIER
SCHEMATIC SHEET 2 OF 2 #40000–438

REV E

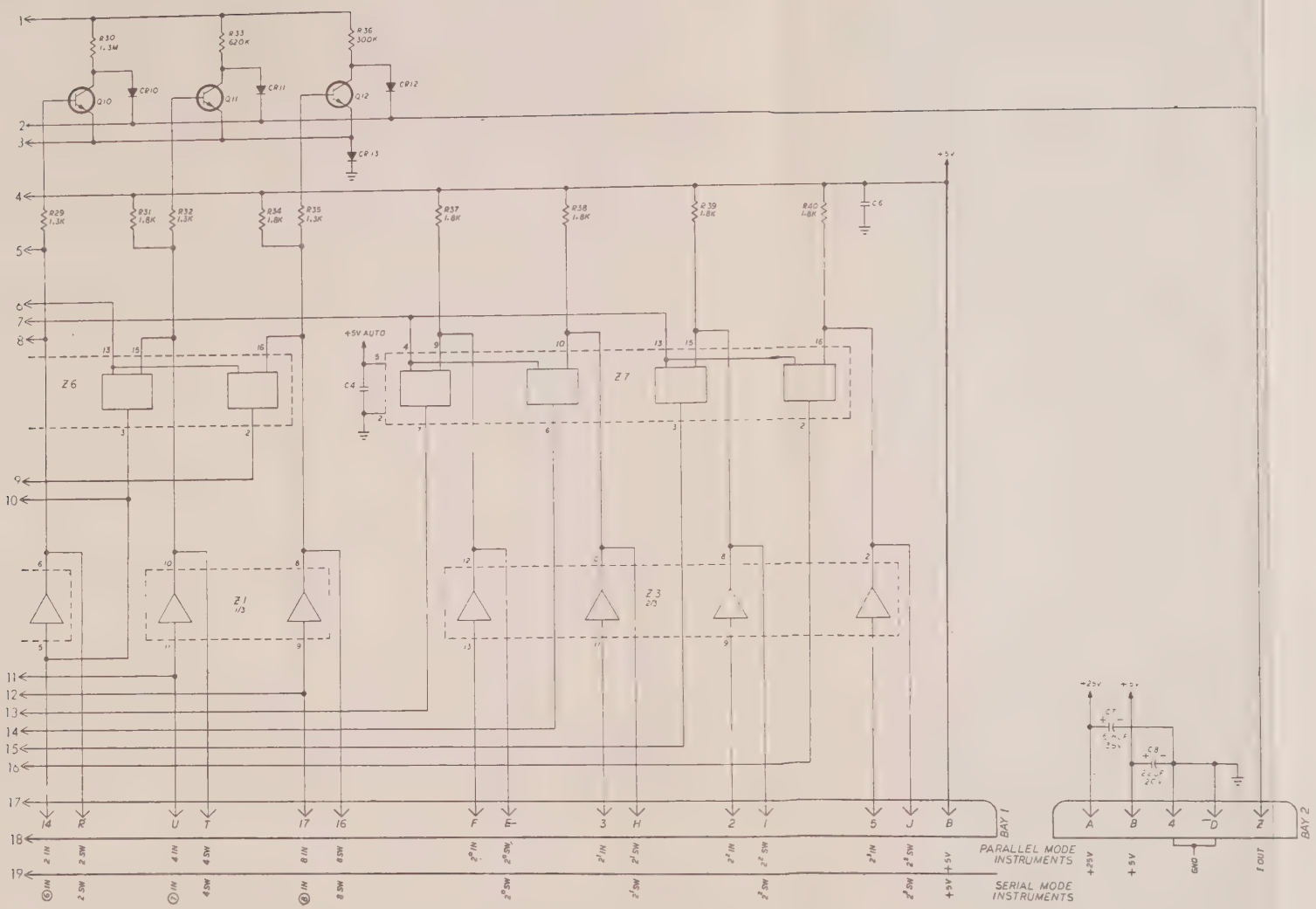


6. For serial to parallel D/A IC's 4-7 are SN7475 and IC 1, 2 & 3 are omitted
5. For GND true parallel D/A 1, 2 & 3 are SN7417 & IC's 4-7 are omitted
4. For positive true parallel D/A IC's 1, 2 & 3 are SN7416 and IC's 4-7 are omitted
3. All transistors are 2N3641 MPS6532
2. All diodes are DP16-0 1N3600
1. All capacitors are .022 μF, 25V

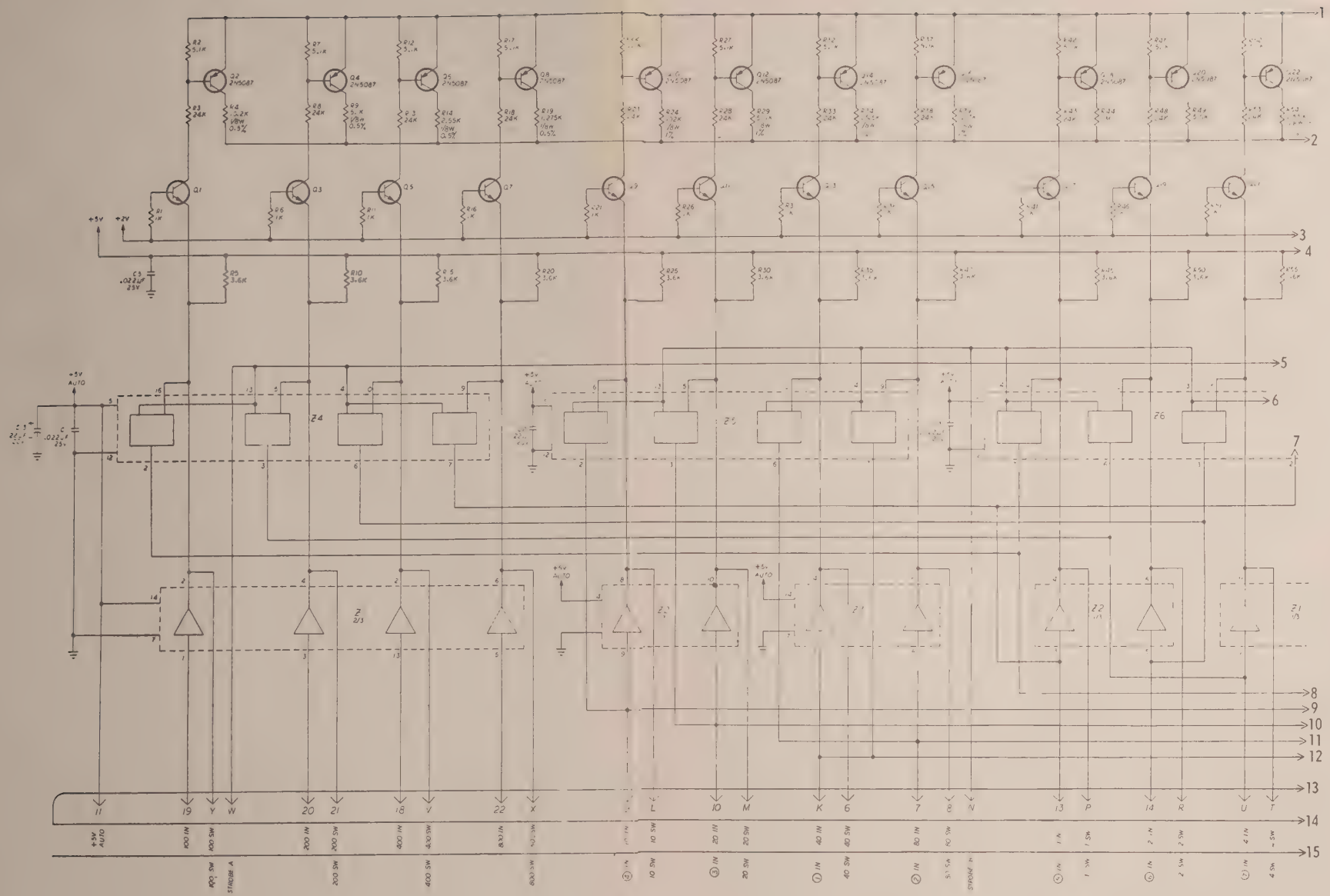
NOTE: Unless otherwise specified

MODEL 153/154—1 and 3
LINEAR D/A CONVERTER SCHEMATIC
SHEET 1 OF 2 =40000—481

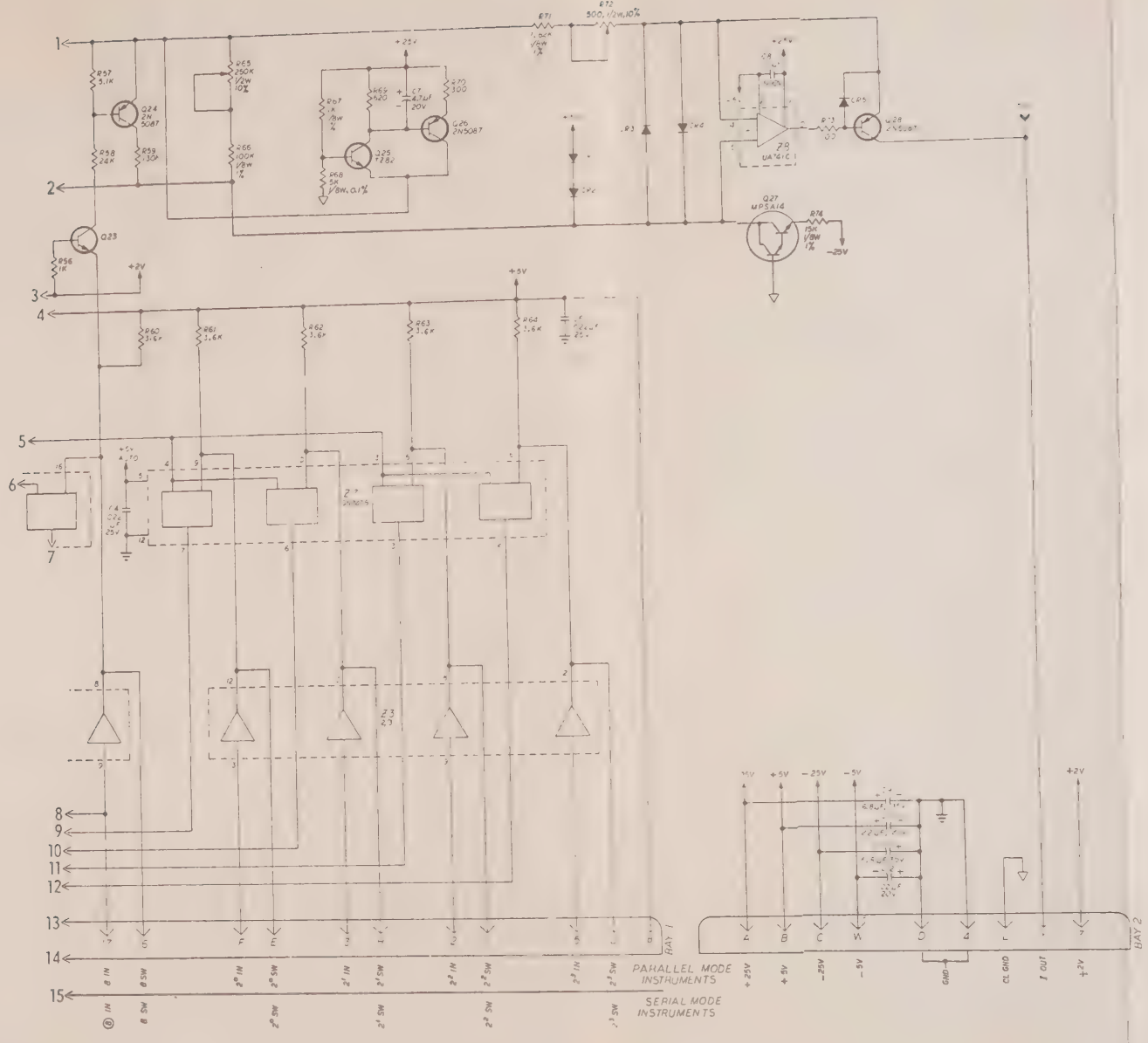
REV A



MODEL 153/154–1 and 3
LINEAR D/A CONVERTER SCHEMATIC
SHEET 2 OF 2 #40000–481
REV A



MODEL 153/154–1 and 3
HYPERBOLIC D/A CONVERTER SCHEMATIC
SHEET 1 OF 2 #40000–482
REV A



6. For serial to parallel D/A IC's 4-7 are SN7475 and IC's 1, 2 & 3 are omitted.
5. For GND true parallel D/A IC's 1, 2 & 3 are SN7417 and IC's 4 7 are omitted.
4. For positive true parallel D/A IC's 1, 2 & 3 are SN7416 and IC's 4-7 are omitted.
3. All transistors are 2N3641/MPS6532
2. All diodes are DP16-0/1N3600
1. All presision resistors are RN60

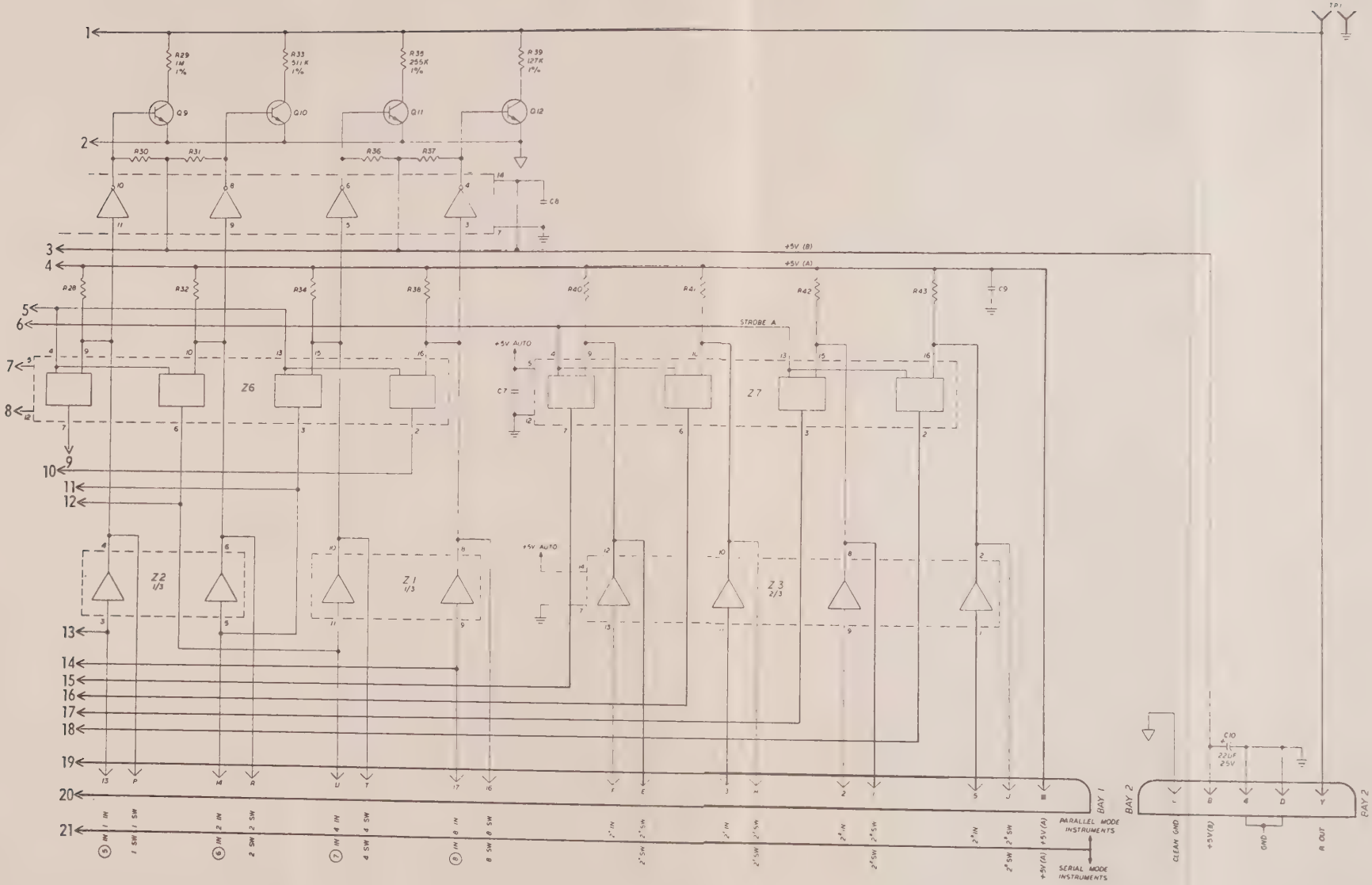
NOTE: Unless otherwise specified

MODEL 153/154—1 and 3
HYPERBOLIC D/A CONVERTER SCHEMATIC
SHEET 2 OF 2 =40000—482
REV A

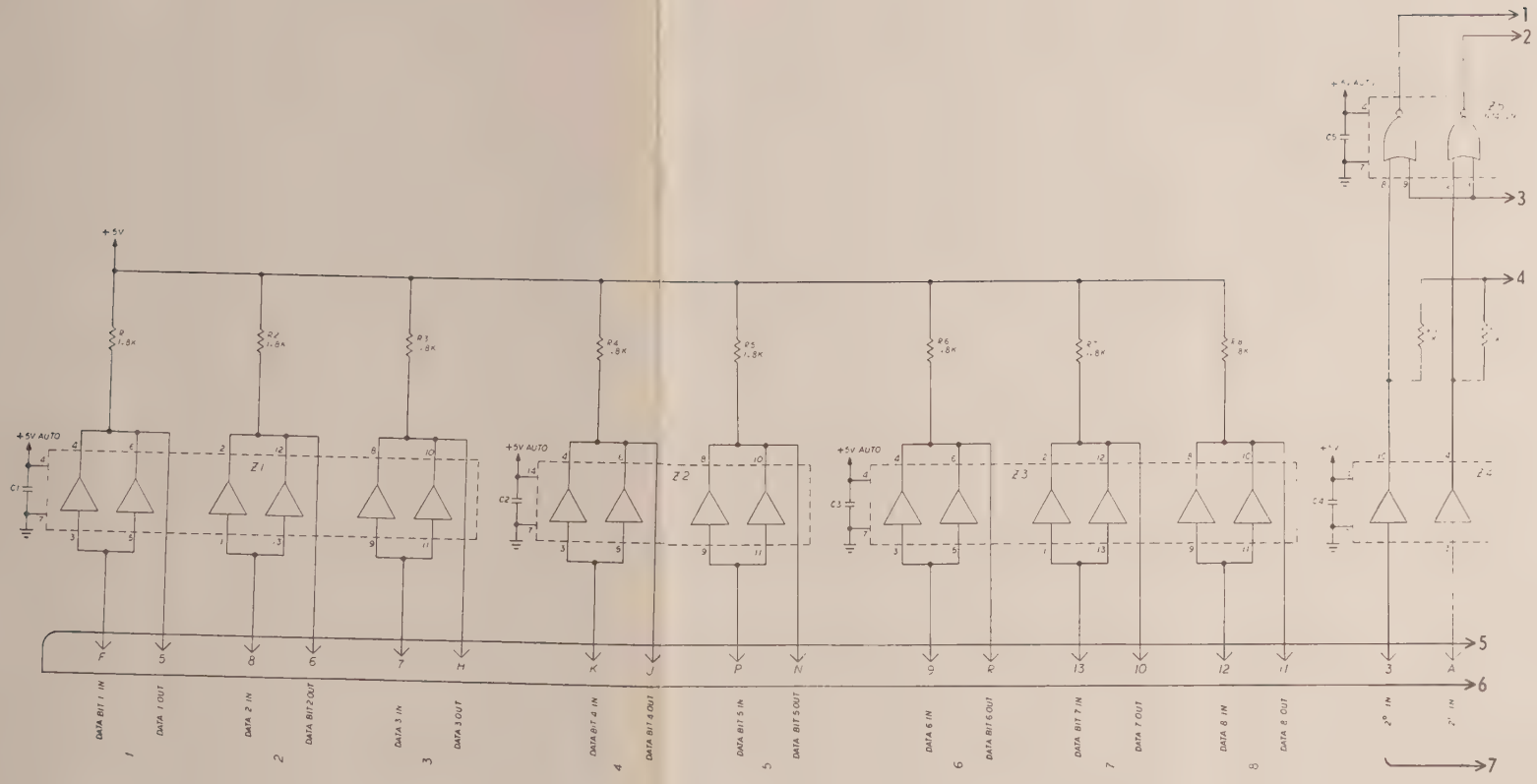
5. For serial to parallel D/A IC's 4-7 are SN7475 and IC's 1, 2 & 3 are omitted
4. For GND true parallel D/A IC's 1, 2 & 3 are SN7417 and IC's 4-7 are omitted
3. For positive true parallel D/A IC's 1, 2 & 3 are SN7416 and IC's 4-7 are omitted
2. All transistors are DP6311
1. All capacitors are .022 μF, 25V

NOTE: Unless otherwise specified

MODEL 153/154–1 and 3
HYPERBOLIC CONDUCTANCE D/A CONVERTER
SCHEMATIC SHEET 1 OF 2 #40000–550



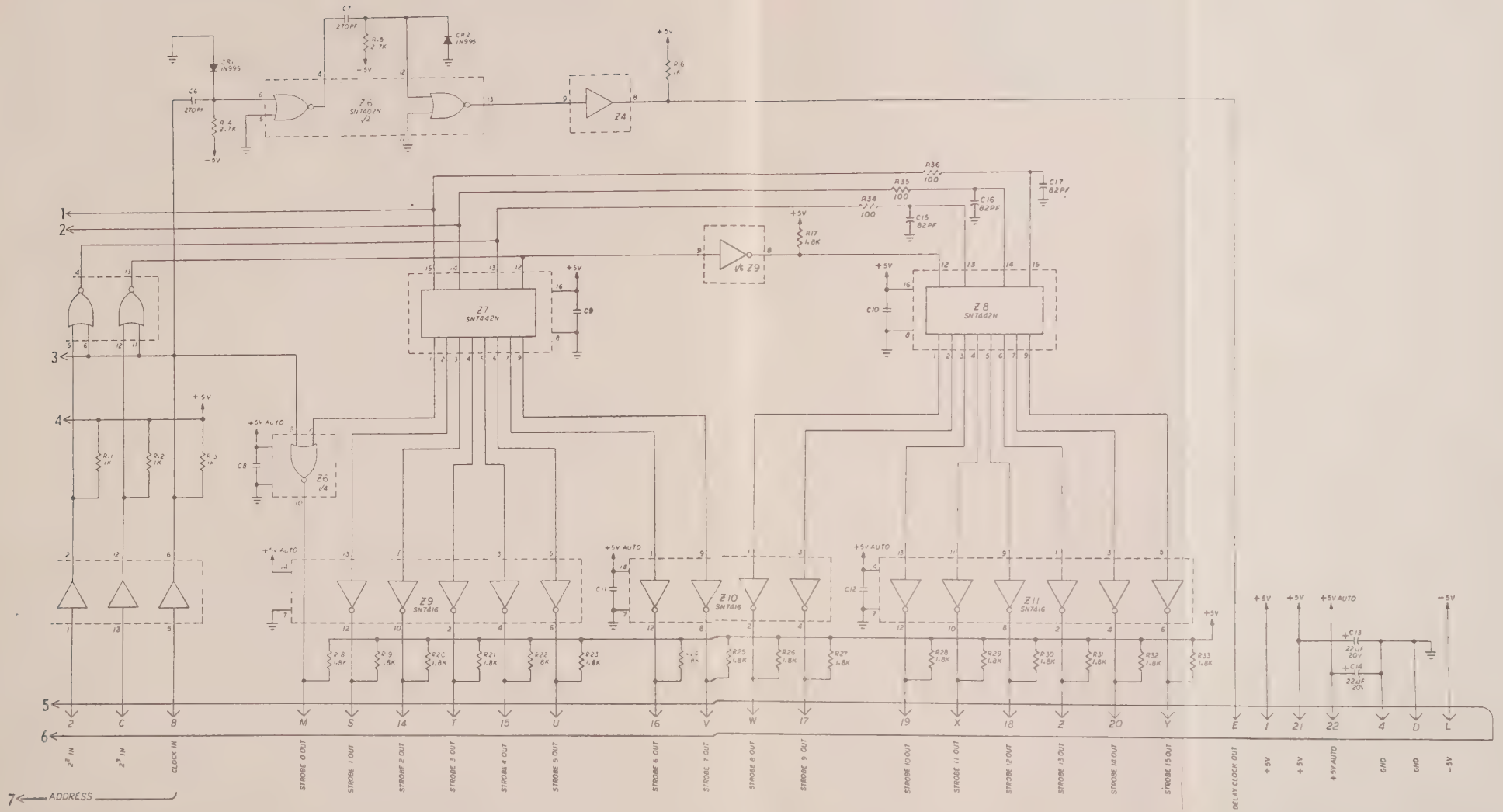
MODEL 153/154–1 and 3
HYPERBOLIC CONDUCTANCE D/A CONVERTER
SCHEMATIC SHEET 2 OF 2 ±40000–550



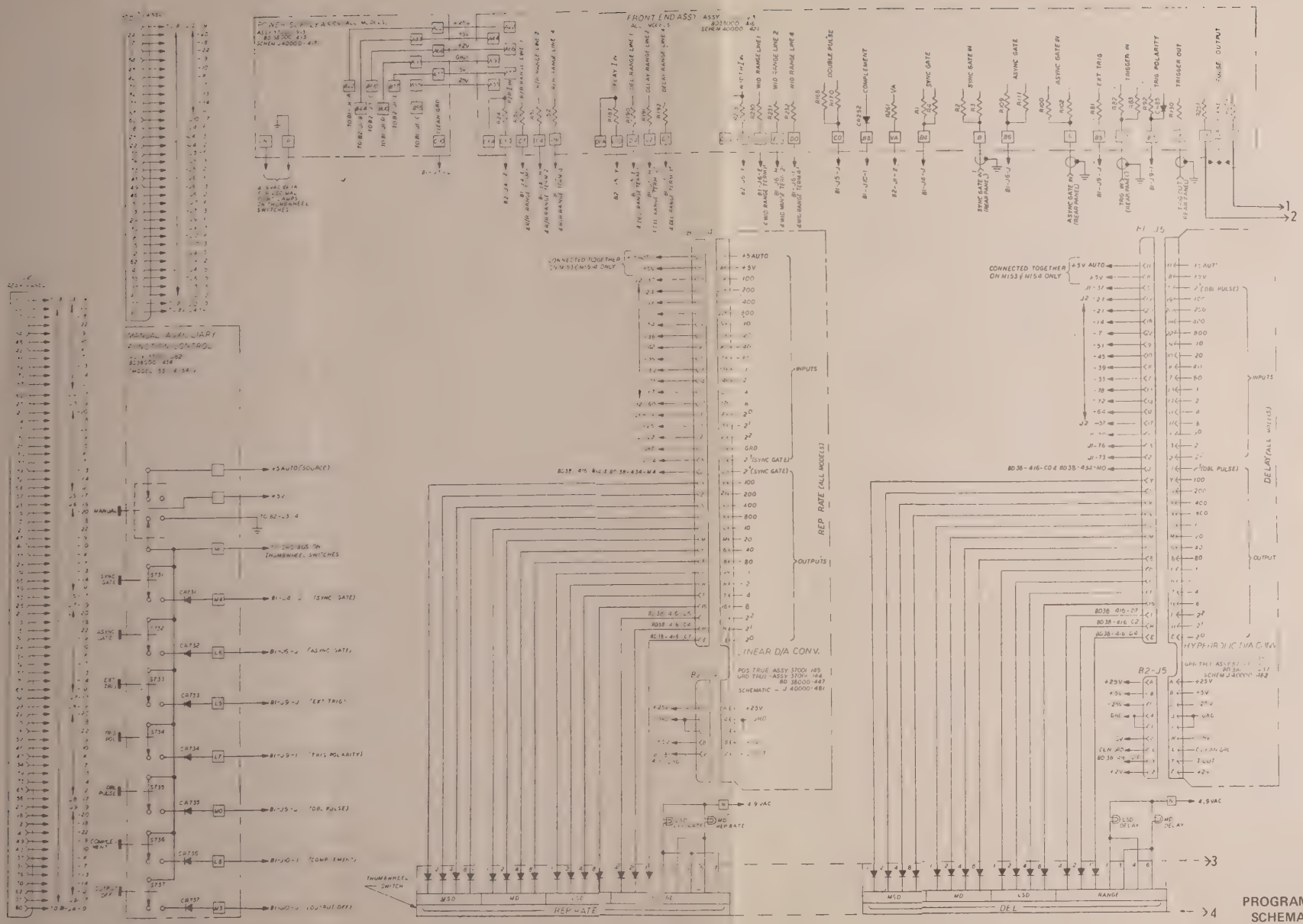
3. For positive true IC's 1-4 are SN7416
2. For GND true IC's 1-4 are SN7417
1. All capacitors are .022 μF, 25V.

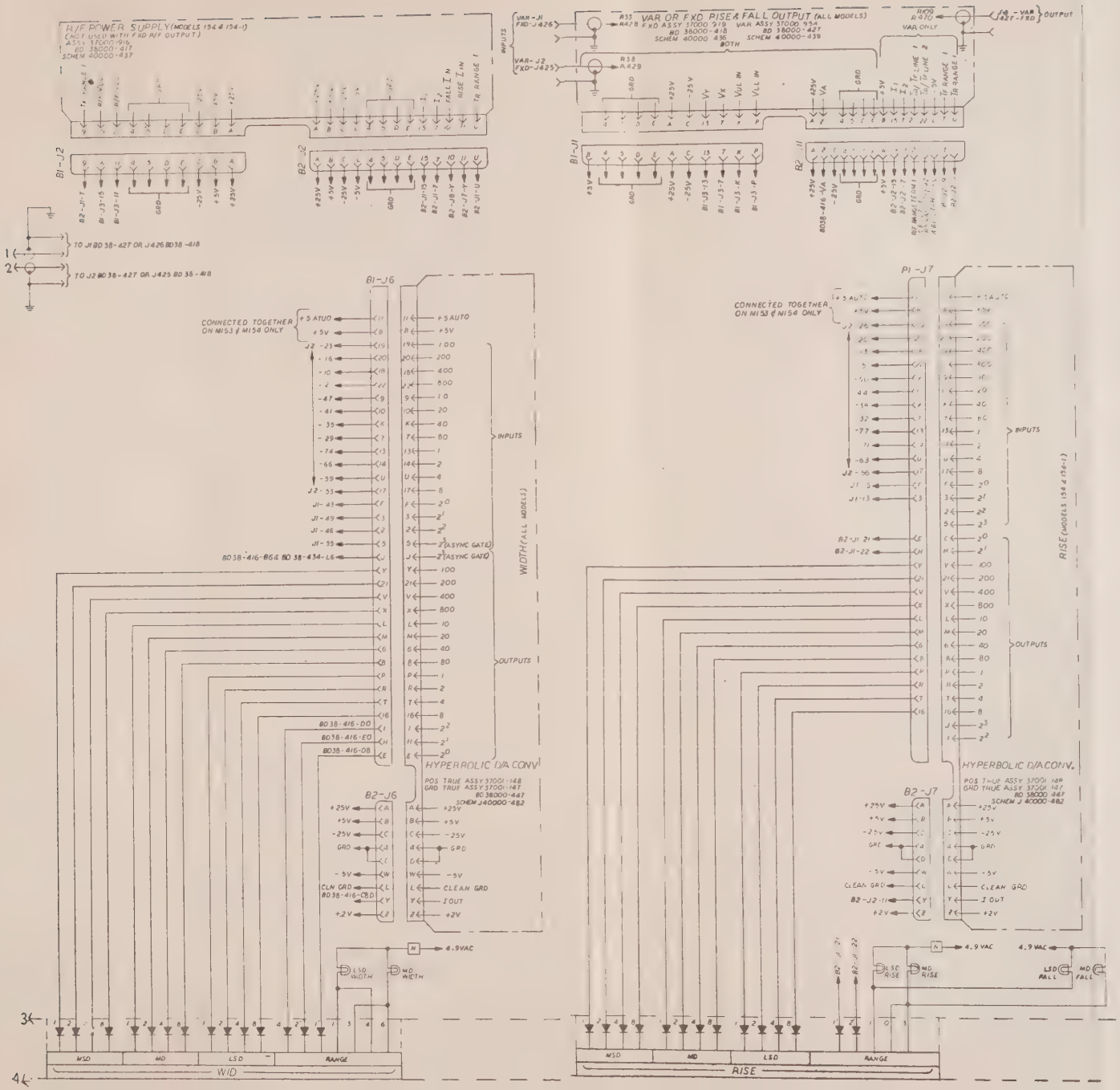
NOTE: Unless otherwise specified

MODEL 153/154–1 and 3
SERIAL TO PARALLEL CONVERTER
SCHEMATIC SHEET 1 OF 2 #40000–483
REV B



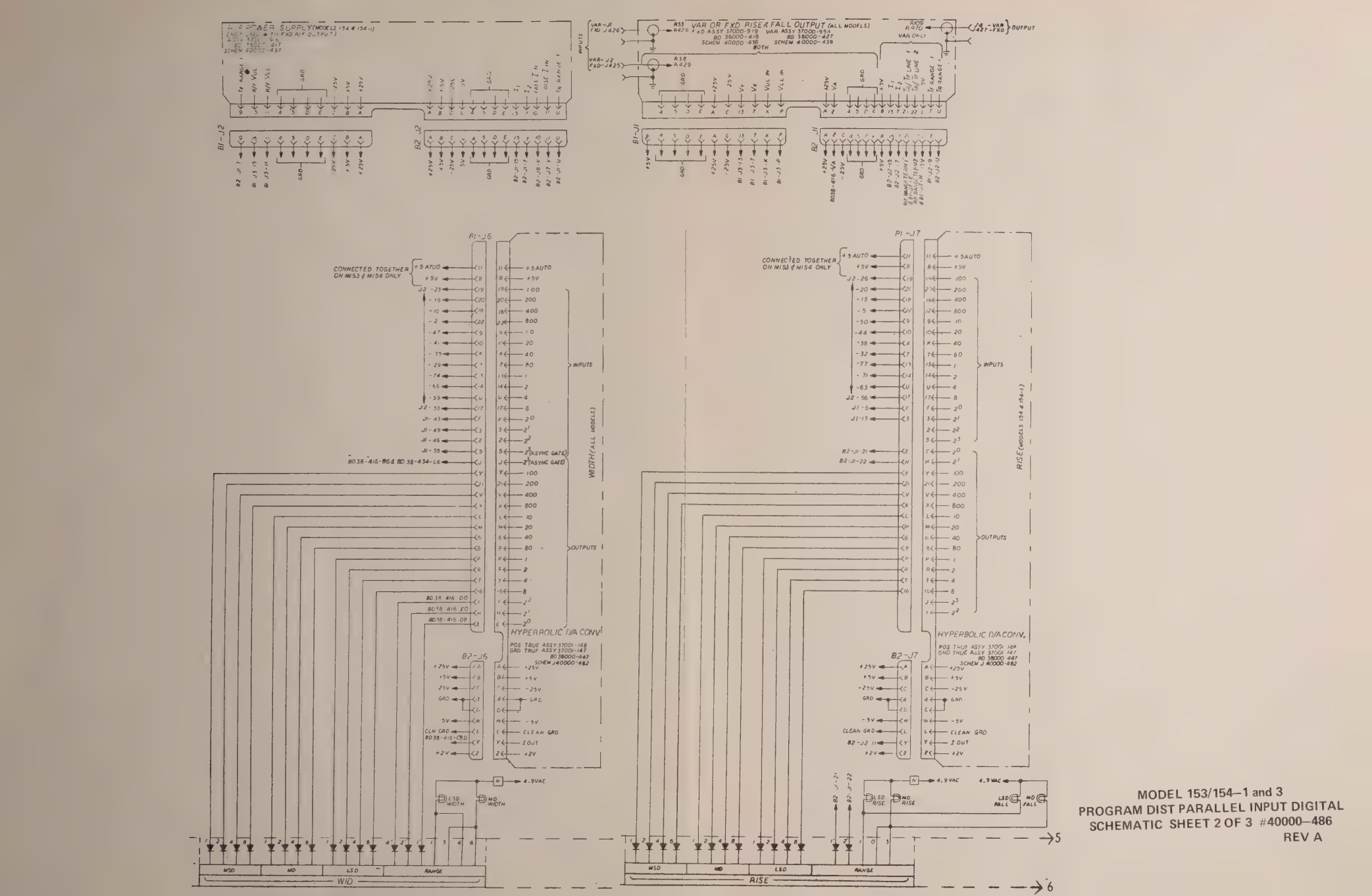
MODEL 153/154—1 and 3
SERIAL TO PARALLEL CONVERTER
SCHEMATIC SHEET 2 OF 2 #40000—483
REV B


FRONT END ASSY
INPUTS
OUTPUTS
REP RATE (ALL MODELS)
DELAY (ALL MODELS)
LINEAR D/A CONV.
HYPERBOLIC D/A CONV.
REP RATE
DEL
MSD
MD
LSD
RANGE
THUMBWHEEL SWITCH
MANUAL AUX JAPT FUNCTION CONTROL
+5AUTO(SOURCE)
+5V
SYNC GATE
ASYNC GATE
EXT TRIG
TRIG POL
DBL PULSE
COMPLEMENT
OUTPUT OFF
(SYNC GATE)
(ASYNC GATE)
(EXT TRIG)
(TRIG POLARITY)
(DBL PULSE)
(COMP EMENT)
(OUTPUT OFF)
CONNECTED TOGETHER ON M153 & M154 ONLY
4.9 VAC
LSD DELAY
MD DELAY
MODEL 153/154–1 and 3
PROGRAM DIST PARALLEL INPUT DIGITAL
SCHEMATIC SHEET 1 OF 3 #40000–486
REV A

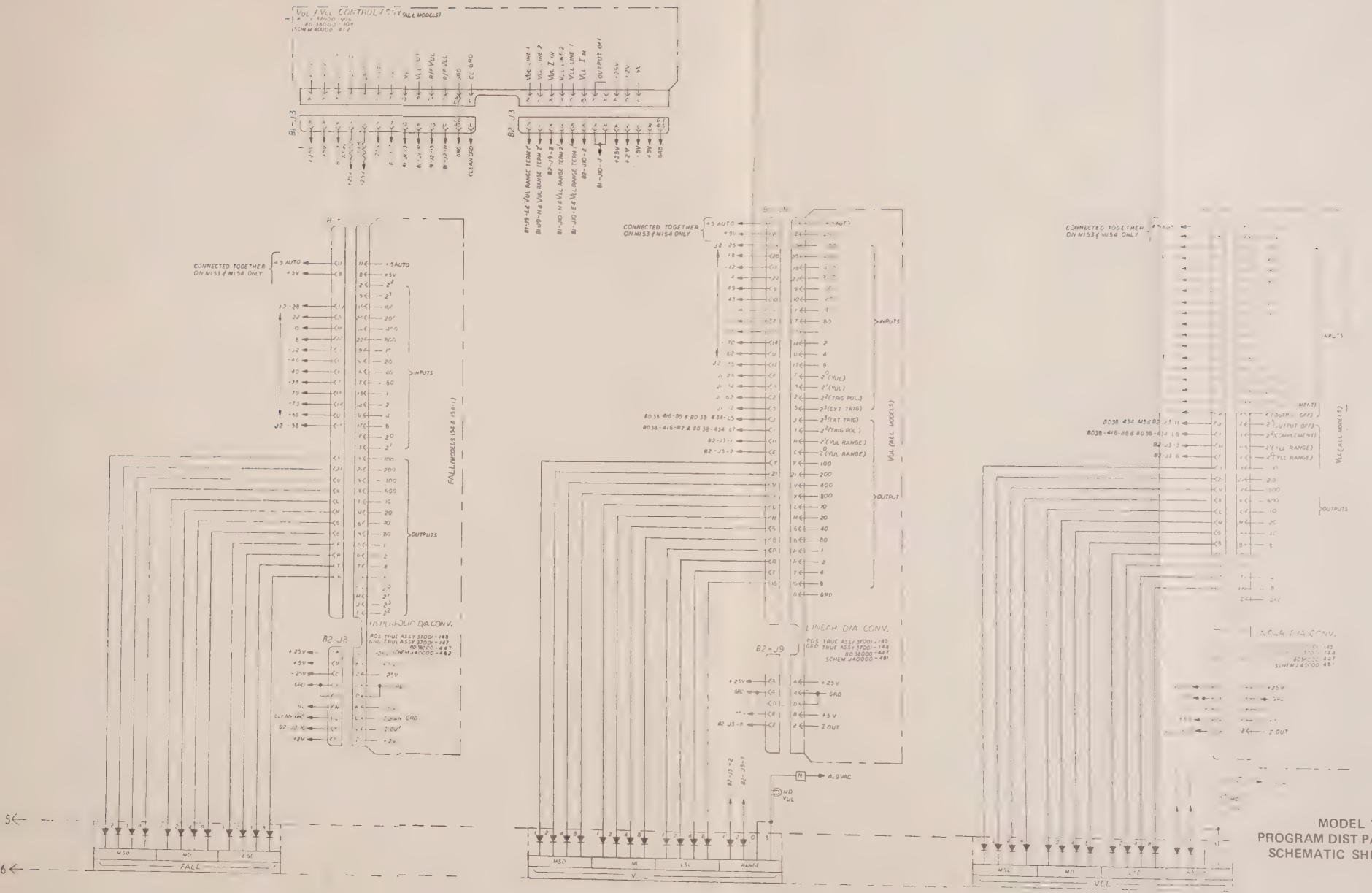


MODEL 153/154–1 and 3
PROGRAM DIST PARALLEL INPUT DIGITAL
SCHEMATIC SHEET 2 OF 3 #40000–486

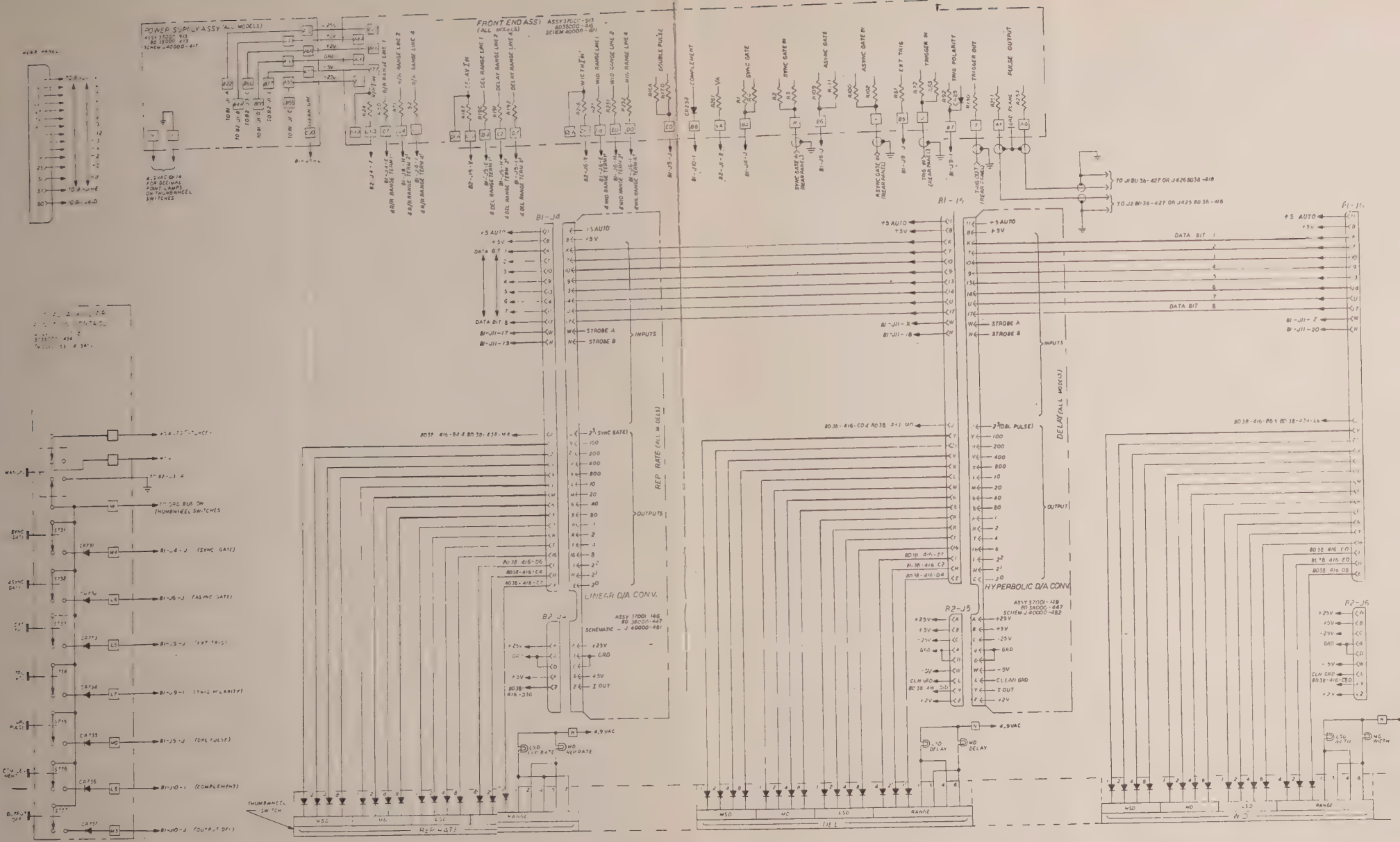
REV A



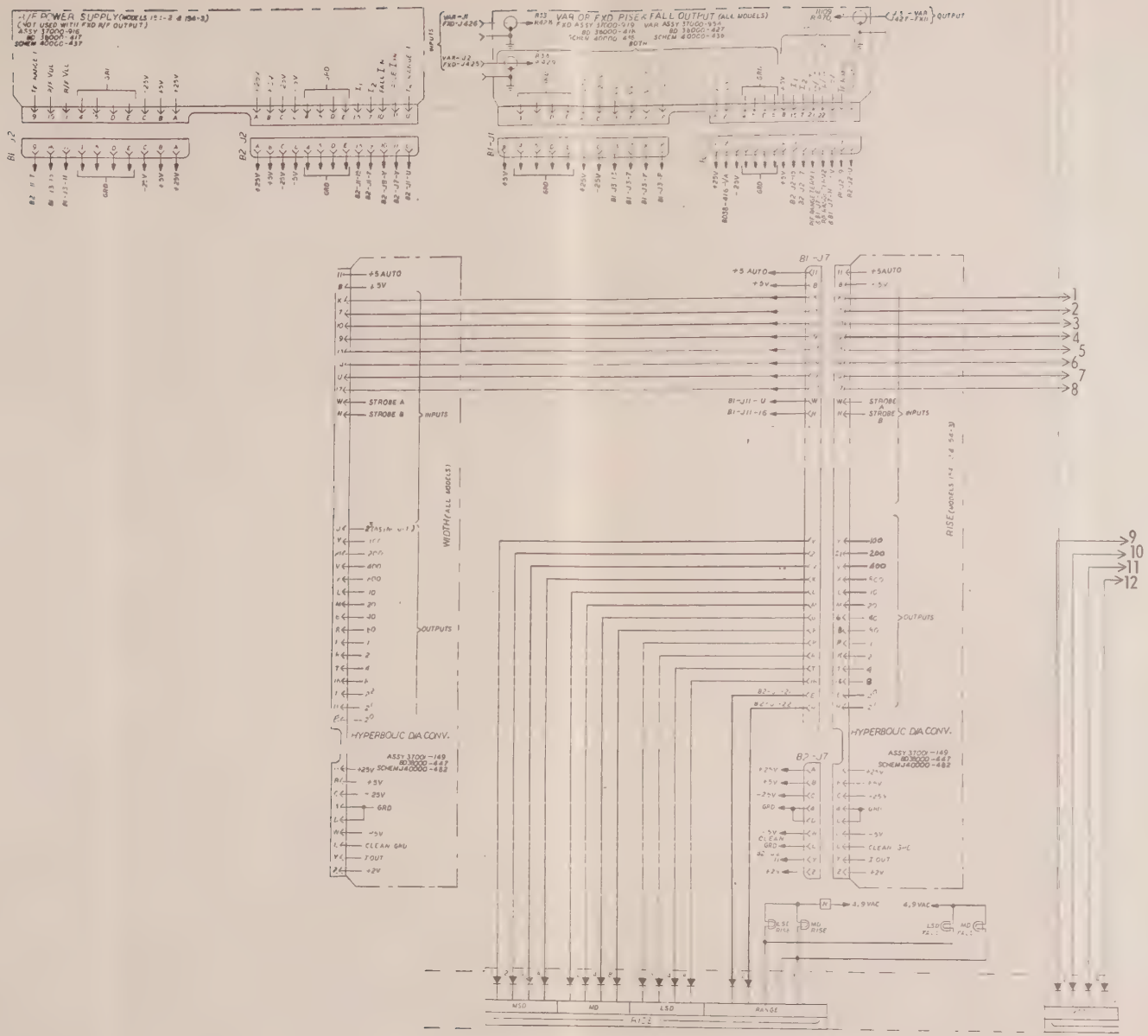
MODEL 153/154–1 and 3
PROGRAM DIST PARALLEL INPUT DIGITAL
SCHEMATIC SHEET 2 OF 3 #40000–486
REV A



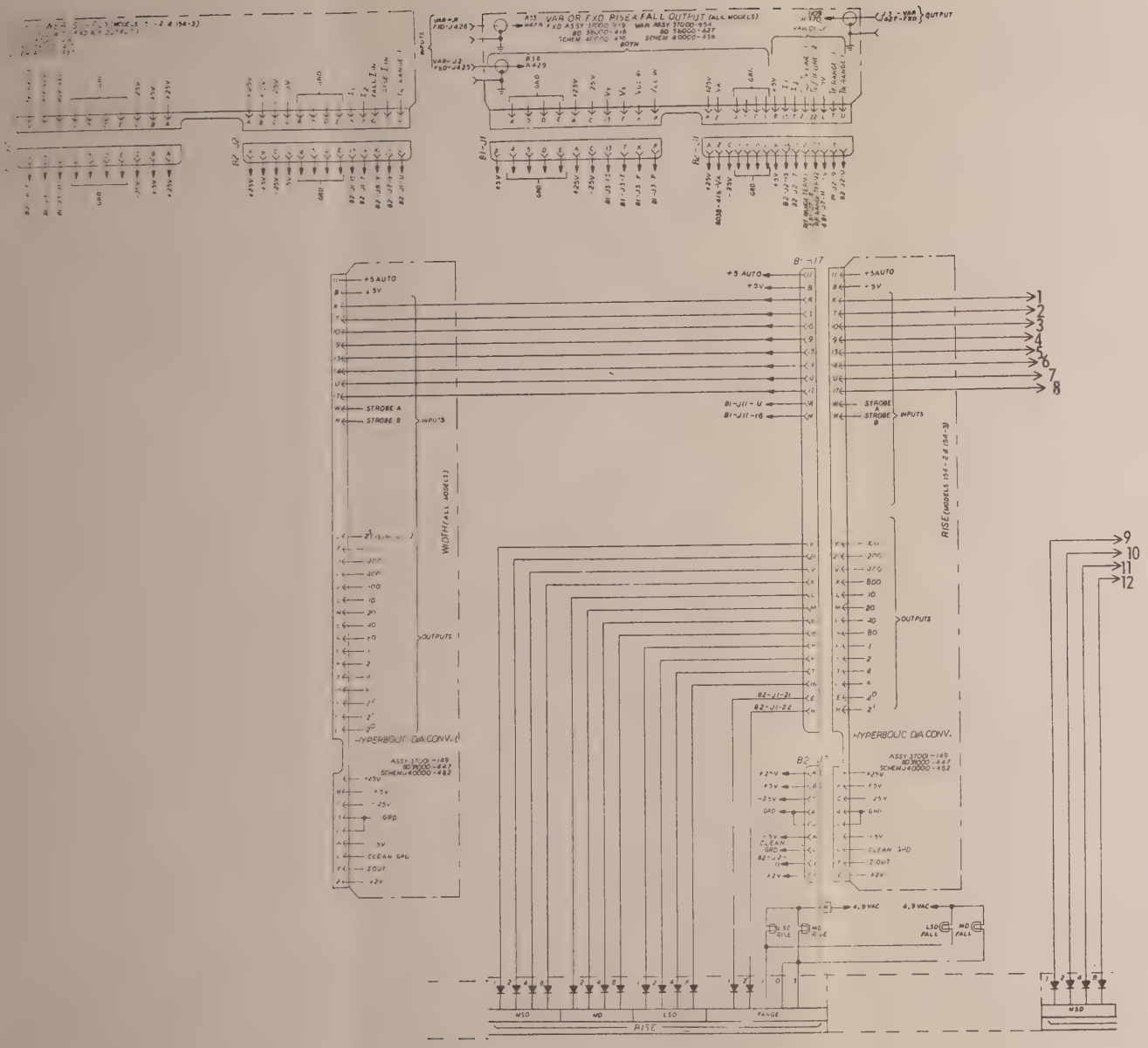
MODEL 153/154–1 and 3
PROGRAM DIST PARALLEL INPUT DIGITAL
SCHEMATIC SHEET 3 OF 3 =40000–486
REV A



MODEL 153/154–1 and 3
PROGRAM DIST SERIAL INPUT DIGITAL
SCHEMATIC SHEET 1 OF 3 #40000–487
REV A

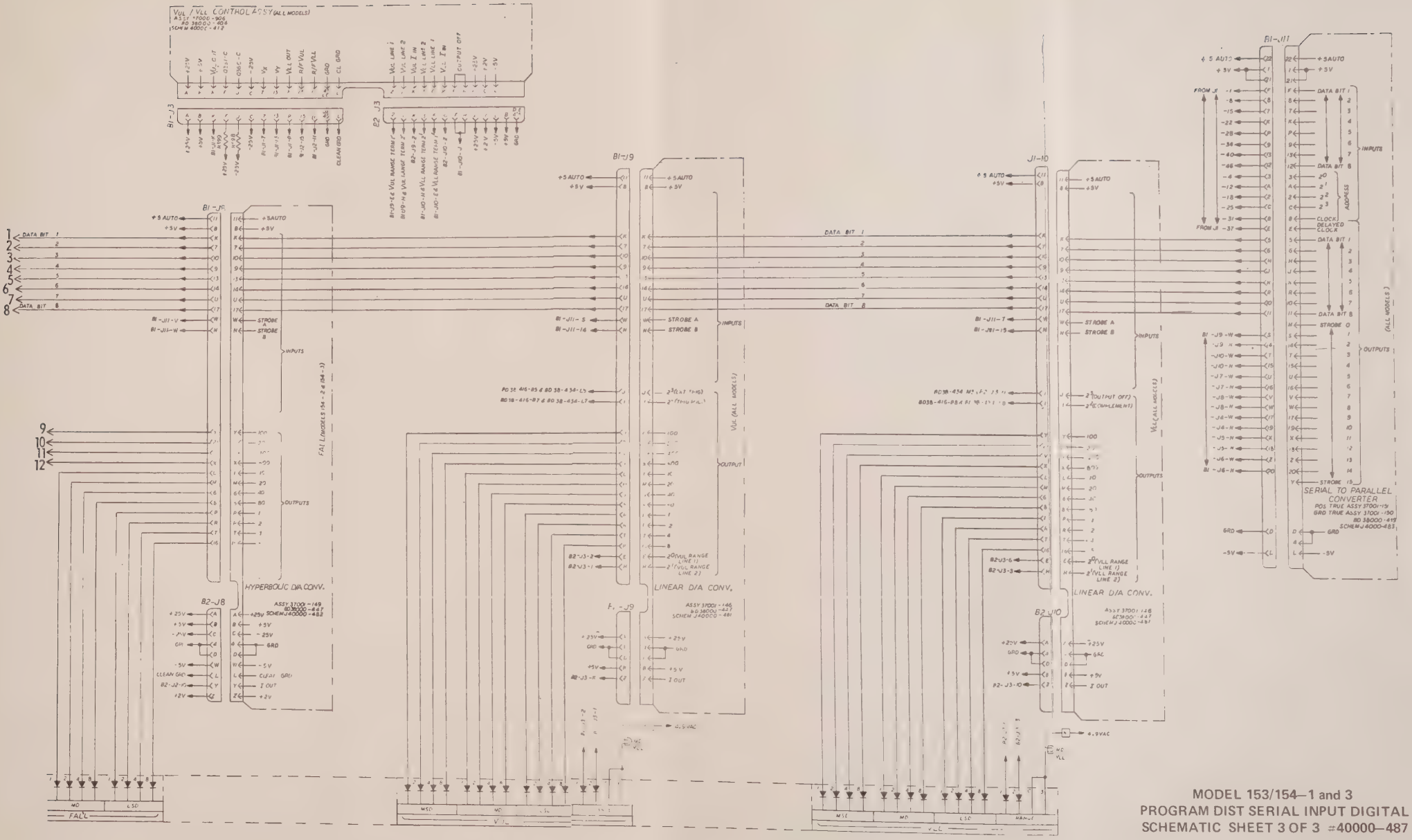


MODEL 153/154—1 and 3
PROGRAM DIST SERIAL INPUT DIGITAL
SCHEMATIC SHEET 2 OF 3 #40000—487
REV A



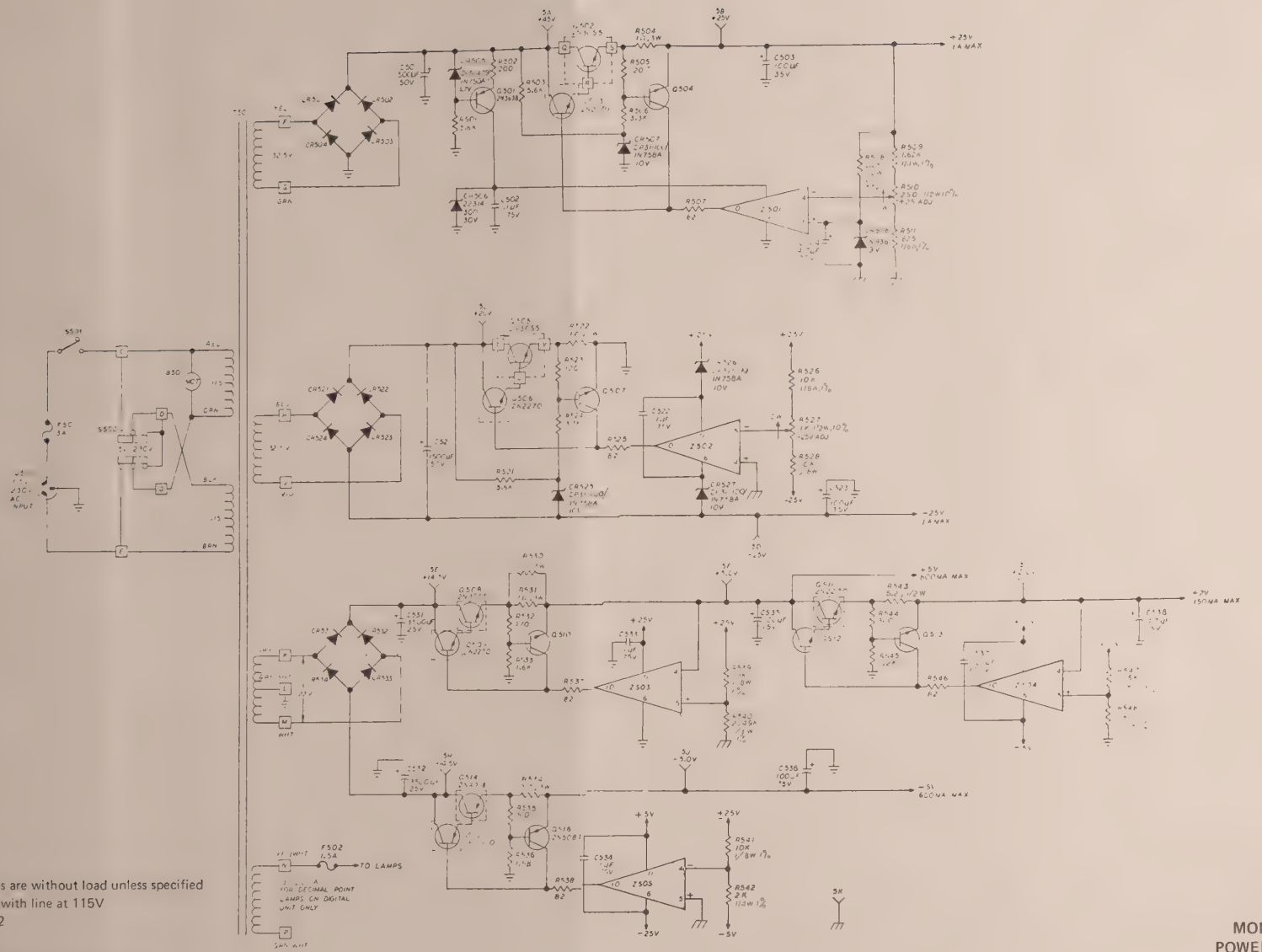
MODEL 153/154–1 and 3
PROGRAM DIST SERIAL INPUT DIGITAL
SCHEMATIC SHEET 2 OF 3 #40000–487

REV A



MODEL 153/154—1 and 3
PROGRAM DIST SERIAL INPUT DIGITAL
SCHEMATIC SHEET 3 OF 3 #40000—487

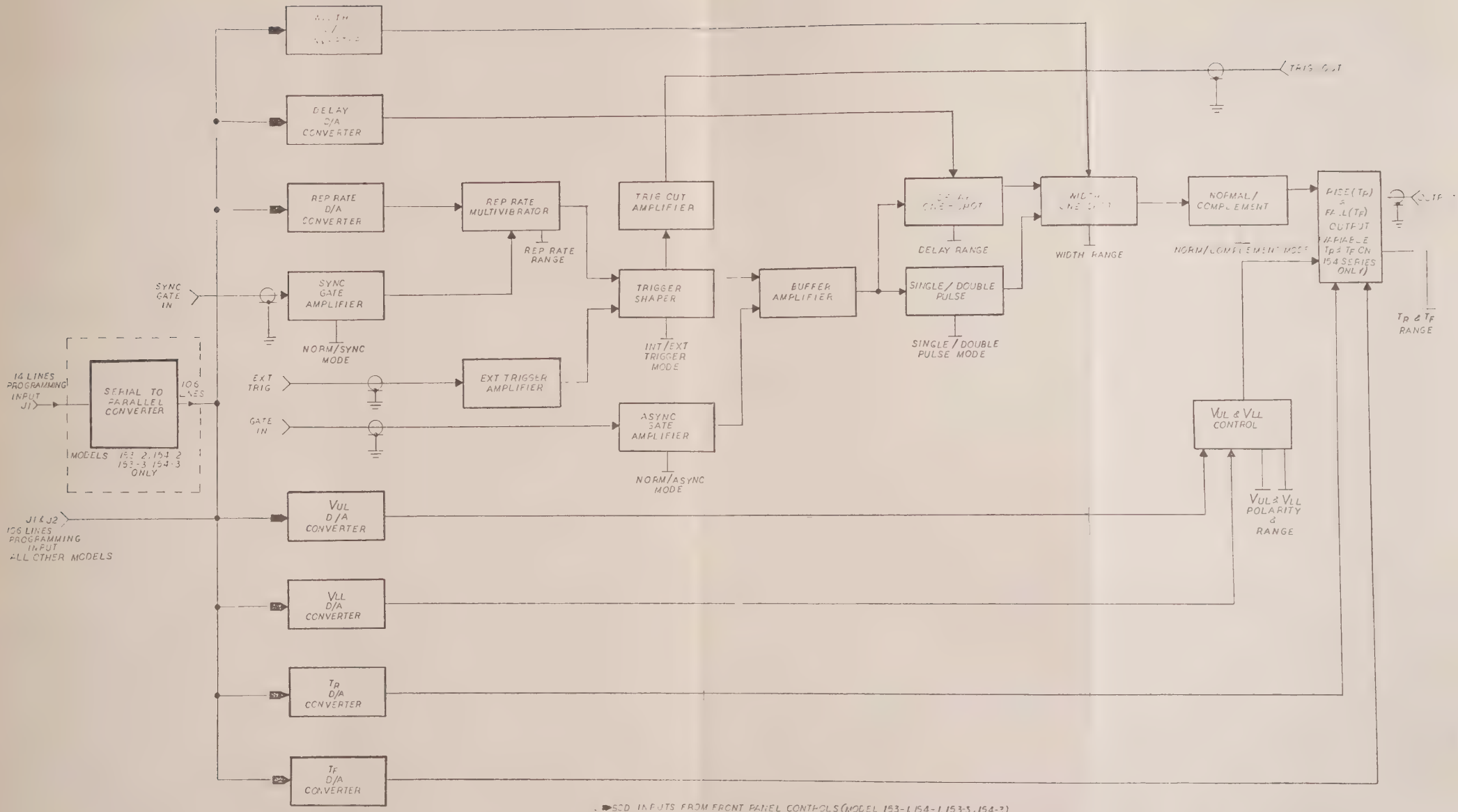
REV A



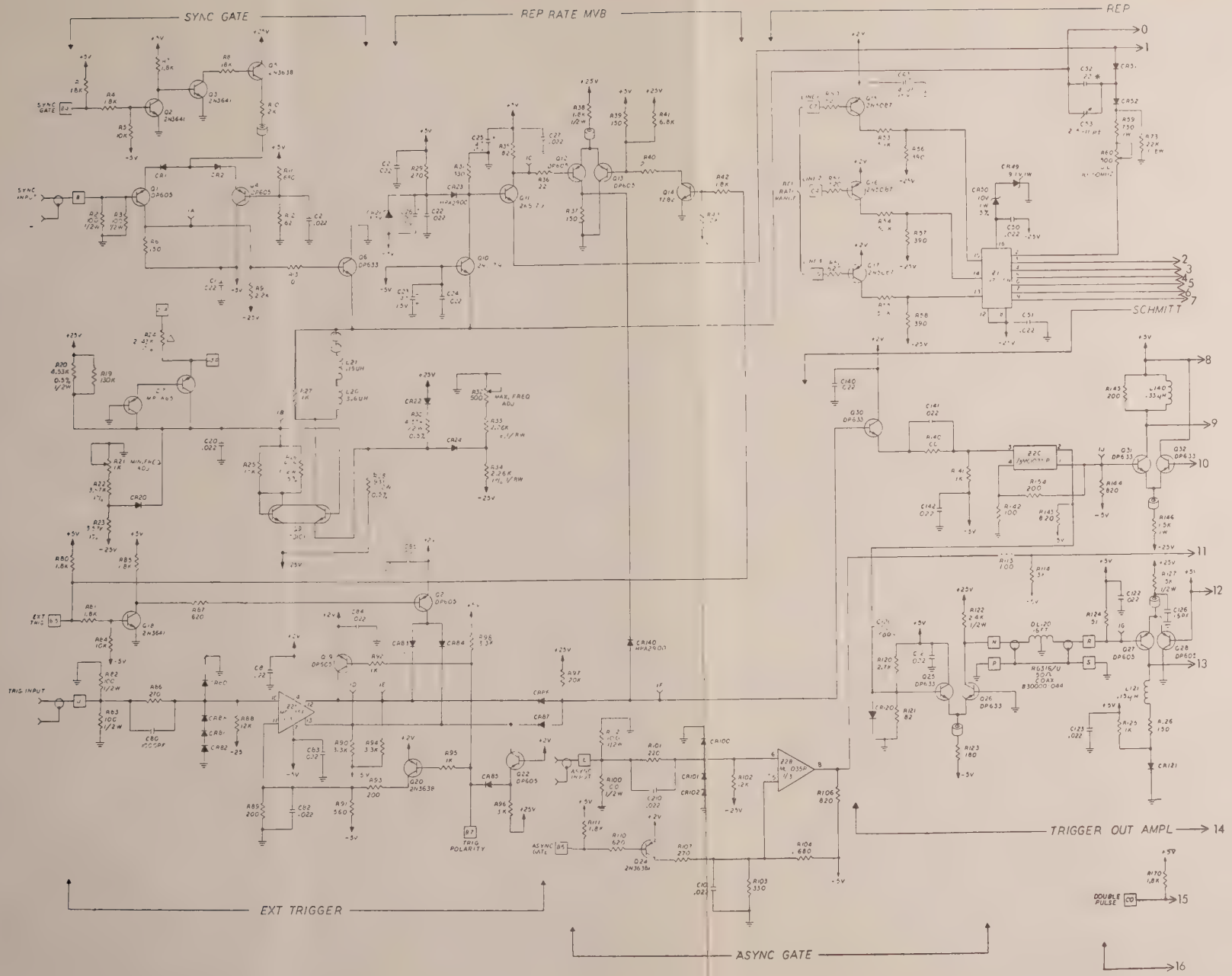
6. All transformer voltages are without load unless specified
5. Test point voltages are with line at 115V
4. All transistors are TZ82
3. All IC's are UA741C
2. All diodes are IRC20A
1. Dotted lines around transistors indicate heatsink

NOTE: Unless otherwise specified

MODEL 153/154–1 and 3
POWER SUPPLY SCHEMATIC
SHEET 1 OF 1 #40000–417
REV C


DELAY D/A CONVERTER
REP RATE D/A CONVERTER
REP RATE MULTIVIBRATOR
REP RATE RANGE
SYNC GATE IN
SYNC GATE AMPLIFIER
NORM/SYNC MODE
TRIG OUT AMPLIFIER
TRIGGER SHAPER
INT/EXT TRIGGER MODE
BUFFER AMPLIFIER
DELAY RANGE
SINGLE/DOUBLE PULSE
SINGLE/DOUBLE PULSE MODE
WIDTH RANGE
NORMAL/COMPLEMENT
NORM/COMPLEMENT MODE
TR & TF RANGE
14 LINES PROGRAMMING INPUT J1
SERIAL TO PARALLEL CONVERTER
106 LINES
MODELS 153-2, 154-2 153-3 154-3 ONLY
EXT TRIG
EXT TRIGGER AMPLIFIER
GATE IN
ASYNC GATE AMPLIFIER
NORM/ASYNC MODE
VUL & VLL CONTROL
VUL & VLL POLARITY & RANGE
J1 & J2 106 LINES PROGRAMMING INPUT ALL OTHER MODELS
VUL D/A CONVERTER
VLL D/A CONVERTER
TR D/A CONVERTER
TF D/A CONVERTER
TRIG OUT
OUTP
TR & TF RANGE
1 SCD INPUTS FROM FRONT PANEL CONTROLS (MODEL 153-1, 154-1, 153-3, 154-3) OR REMOTE PROGRAMMING SOURCE (MODEL 153, 153-1, 154, 154-1, 153-2, 154-2)
1 LOGIC INPUTS FOR MODE & RANGE SELECTION FROM FRONT PANEL CONTROLS (MODEL 153-1, 154-1, 153-3, 154-3 OR REMOTE PROGRAMMING SOURCE (MODEL (153, 153-1, 154, 154-1, 153-2, 154-2)
NOTE, UNLESS OTHERWISE SPECIFIED

MODEL 153/154—1 and 3
BLOCK DIAGRAM #41000—230
REV A



MODEL 153/154—1 and 3
FRONT END BOARD SCHEMATIC
SHEET 1 OF 2 #40000—421
REV E

MANUAL CHANGES

The following pages relate to the Model 154-4 Supplement to the Model 153/154 - 1 and 3 Programmable Pulse Generators.

A51834

The Model 154-4 digitally programmable pulse generator is designed for use in automatic systems for the testing of integrated circuits and other solid state devices. Front panel controls allow for use in conventional pulse generator laboratory applications. The instrument operates at repetition rates up to 50 MHz, delay and width up to 10 ms, transition times less than 5 ns and amplitudes up to 10 volts. All parameters, repetition rates, delay, width, upper and lower voltage levels (amplitude) pulse polarity and transition times can be controlled from a remote controller device via the IEEE STD-488 General Purpose Interface Bus (GPIB).

154-4 SUPPLEMENT

PULSE GENERATORS

SN 30016-8

1.18.3 IEEE STD-488 Interface (Model 154-4 Only)

Refer to IEEE STD-488 1975 for GPIB specifications and paragraph 3.3.3 of this supplement for the detailed operating instructions for the GPIB Interface.

2.20 IEEE-488 INTERFACE

Connector	24-pin metric dimensioned connector per IEEE STD-488 GPIB.
Address	5-rocker switches which allows selection of the Listen address assignments per IEEE STD-488.

3.3.3 IEEE STD-488 GPIB (Model 154-4)

The Model 154-4 Pulse Generator may be operated via the General Purpose Interface Bus (GPIB). The Pulse Generator can be controlled by, and talked to by, any device or devices that are IEEE STD-488 compatible.

The IEEE STD-488 GPIB system consists of a set of sixteen signal lines that are used to carry data information, interface messages and device dependent messages between different devices connected to the bus.

The GPIB is organized into three sets of signal lines:

1. Data bus, 8 signal lines (7 are actively used by the 154-4).
2. Data byte transfer control bus, 3 signal lines.
3. Interface management control bus, 5 signal lines (2 are actively used by the 154-4).

Figure 3-3 illustrates the GPIB structure and it's interface capabilities.

NOTE

For complete details on the electrical, mechanical and timing requirements, refer to IEEE STD-488-1975.

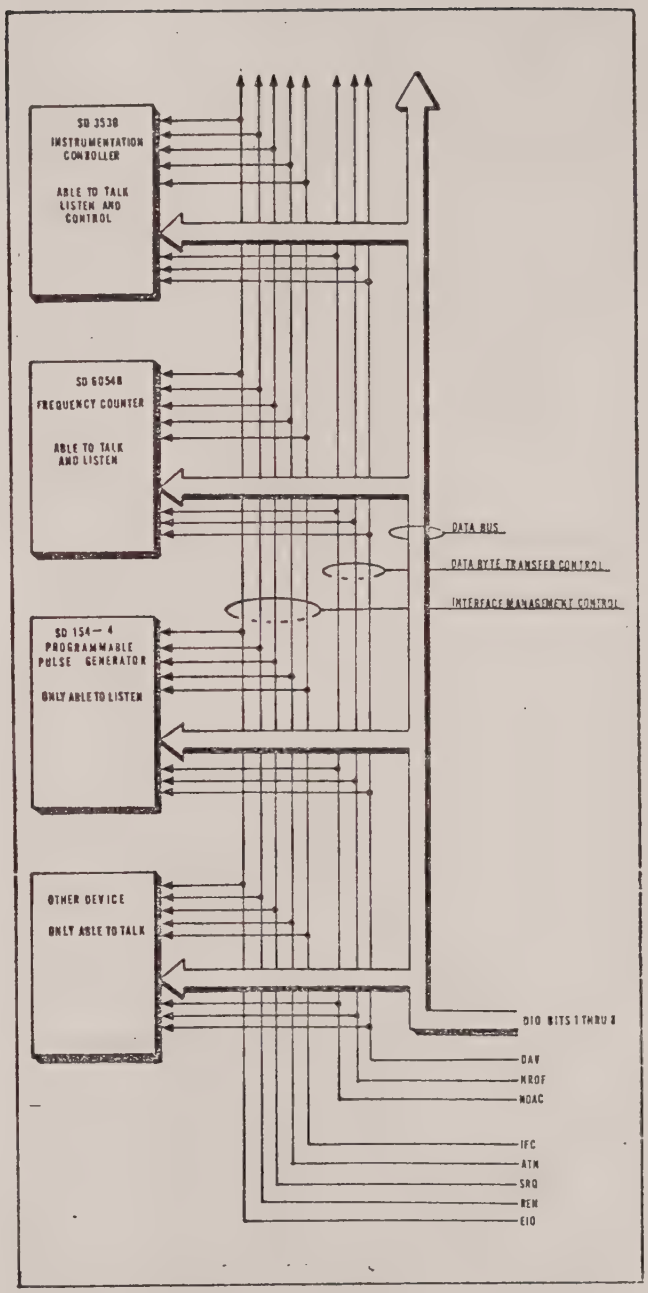


FIGURE 3-3
GPIB INTERFACE CAPABILITIES AND BUS STRUCTURE

The bus interface lines are assigned IEEE-STD-488 mnemonics which are defined as follows:

DIO1 through DIO8: Data Input/Output lines 1 through 8, transmitted message bytes in bit parallel, byte serial format, asynchronously and in a bi-directional manner.

DAV: Data Valid, indicates the availability of data on the DIO lines.

NFRD: Not Ready For Data, indicates when the device is ready to accept data.

ATN: Attention, indicates how the data on the DIO lines is to be interpreted, and which devices will respond to the data.

IFC: Interface Clear, is used to set the interface system, and the devices connected to it into a known quiescent state.

NDAC: Data Not Accepted, indicates when the data received was accepted.

SRQ:* Service Request, is used to request service from a controller.

REN:* Remote Enable, is used by a controller device (in conjunction with other messages generated in the local logic) to place the Pulse Generator in the Remote Mode of operation.

EOI:* End Or Identify, is used to indicate the end of a data transfer or, with the ATN line to execute a polling sequence.

*These lines are not used by the Model 154-4 Pulse Generator, and are set in the tri state.

The 154-4 Pulse Generator may be on or off line as selected by the front panel MAN CONT switch. When the MAN CONT pushbutton switch is latched in the parameters can be controlled by the front panel controls. When the pushbutton switch is latched out, the parameters may be controlled by an instrumentation controller, a calculator or any other devices that are IEEE STD-488 compatible controllers. When power is applied to the Pulse Generator, it "wakes up" to the following conditions:

1. The Pulse Generator is placed in the Monitor Mode (unaddressed state).

2. All interim (input) and memory registers are set to zero.

TABLE 3-2 GPIB INTERFACE CONNECTOR

PIN NO.	IEEE STD-488 MNEMONIC	PIN NO.	IEEE STD-488 MNEMONIC
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8(not used)
5	EIO(not used)	17	REN
6	DAV	18	GND(Return)
7	NFRD	19	GND(Return)
8	NDAC	20	GND(Return)
9	IFC	21	GND(Return)
10	SRQ(not used)	22	GND(Return)
11	ATN	23	GND(Return)
12	GND(Shield)	24	GND(Logic)

The "handshake" process functions as follows:

The IFC command is issued by the controller device and will cause the Pulse Generator to monitor the GPIB for further instructions. If the Pulse Generator was addressed as a listener, it will be unaddressed.

The addressing process is controlled by the GPIB ATN line and functions as follows:

1. The Pulse Generator is addressed to Listen by the controller issuing it's assigned Listen address while the ATN line is set active.

2. If the Pulse Generator was addressed to Listen, and the Unlisten (UNL) ASCII ? command is issued by the controller, the Pulse Generator will deselect as a listener.

The Listen address is selected by the Rear Panel 5-digit address switch. The setting of the 5-digit switch determines which Listen address will be

assigned to the Pulse Generator. Thirty-one Listen addresses may be assigned, refer to Table 3-3 for the address to ASCII Code format.

NOTE

A 1-1-1-1-1 address must not be assigned to any device interfacing the bus; these addresses are reserved for the unlisten ASCII (?).

TABLE 3-3
LISTEN ADDRESS ASSIGNMENTS
VS. ASCII CHARACTER

ADDRESS SWITCH SETTING BITS					ASCII CHARACTER
5	4	3	2	1	
0	0	0	0	0	SP
0	0	0	0	1	!
0	0	0	1	0	"
0	0	0	1	1	#
0	0	1	0	0	$
0	0	1	0	1	%
0	0	1	1	0	&
0	0	1	1	1	'
0	1	0	0	0	(
0	1	0	0	1	)
0	1	0	1	0	*
0	1	0	1	1	+
0	1	1	0	0	,
0	1	1	0	1	–
0	1	1	1	0	.
0	1	1	1	1	/
1	0	0	0	0	0
1	0	0	0	1	1
1	0	0	1	0	2
1	0	0	1	1	3
1	0	1	0	0	4
1	0	1	0	1	5
1	0	1	1	0	6
1	0	1	1	1	7
1	1	0	0	0	8
1	1	0	0	1	9
1	1	0	1	0	:
1	1	1	1	1	;
1	1	1	0	0	<
1	1	1	0	1	=
1	1	1	1	0	>
⊕1	1	1	1	1	?

⊕Not to be device assigned. Refer to note.

The IEEE STD-488 Multiline Interface Messages relate to ASCII code. Table 3-4 provides the IEEE STD-488 DIO bit to ASCII code relationships.

TABLE 3-4
IEEE STD-488 DIO CODE
TO ASCII CHARACTER

IEEE STD-488 DIO BIT							ASCII CHARACTER
7	6	5	4	3	2	1	
0	1	0	0	0	0	0	SP
0	1	0	0	0	0	1	!
0	1	0	0	0	1	0	"
0	1	0	0	0	1	1	#
0	1	0	0	1	0	0	$
0	1	0	0	1	0	1	%
0	1	0	0	1	1	0	&
0	1	0	0	1	1	1	'
0	1	0	1	0	0	0	(
0	1	0	1	0	0	1	)
0	1	0	1	0	1	0	*
0	1	0	1	0	1	1	+
0	1	0	1	1	0	0	,
0	1	0	1	1	0	1	–
0	1	0	1	1	1	0	.
0	1	0	1	1	1	1	/
0	1	1	0	0	0	0	Ø
0	1	1	0	0	0	1	1
0	1	1	0	0	1	0	2
0	1	1	0	0	1	1	3
0	1	1	0	0	0	0	4
0	1	1	0	1	0	1	5
0	1	1	0	1	1	0	6
0	1	1	0	1	1	1	7
0	1	1	1	0	0	0	8
0	1	1	1	0	0	1	9
0	1	1	1	0	1	0	:
0	1	1	1	0	1	1	;
0	1	1	1	1	0	0	<
0	1	1	1	1	0	1	=
0	1	1	1	1	1	0	>
0	1	1	1	1	1	1	?
1	0	0	0	0	0	0	@
1	0	0	0	0	0	1	A
1	0	0	0	0	1	0	B
1	0	0	0	0	1	1	C
1	0	0	0	1	0	0	D
1	0	0	0	1	0	1	E
1	0	0	0	1	1	0	F
1	0	0	0	1	1	1	G
1	0	0	1	0	0	0	H
1	0	0	1	0	0	1	I
1	0	0	1	0	1	0	J

TABLE 3-4
IEEE STD-488 DIO CODE
TO ASCII CHARACTER (Cont)

IEEE STD-488 DIO BIT							ASCII
7	6	5	4	3	2	1	CHARACTER
1	0	0	1	0	1	1	K
1	0	0	1	1	0	0	L
1	0	0	1	1	0	1	M
1	0	0	1	1	1	0	N
1	0	0	1	1	1	1	O
1	0	1	0	0	0	0	P
1	0	1	0	0	0	1	Q
1	0	1	0	0	1	0	R
1	0	1	0	0	1	1	S
1	0	1	0	1	0	0	T
1	0	1	0	1	0	1	U
1	0	1	0	1	1	0	V
1	0	1	0	1	1	1	W
1	0	1	1	0	0	0	X
1	0	1	1	0	0	1	Y
1	0	1	1	0	1	0	Z
1	0	1	1	0	1	1	[
1	0	1	1	1	0	0	\
1	0	1	1	1	0	1	]
1	0	1	1	1	1	0	^
1	0	1	1	1	1	1	—

The Pulse Generator can be programmed by sending device dependent messages during the Pulse Generator's Listen mode of operation. The Pulse Generator will ignore any device dependent or independent command for which it has not been designed or programmed to respond to.

Device dependent data is programmed into the Pulse Generator in 2 word serial groups, consisting of 3 serial bytes each. Each byte consists of 7 parallel bits.

The program format is in "Letter–Number–Number" bytes with two bytes to a word, where the Letter (Alpha) is the function word address and the numbers are two bytes of data, either range and MSD or SSD and LSD.

Three different message examples are provided to show the general format structure.

Example 1. To program the VUL to +2.50 volts an entry of A32B5Ø ASCII is programmed in the following sequence:

BYTE BITS							ASCII	FUNCTION
7	6	5	4	3	2	1	CHARACTER	
1	0	0	0	0	0	1	A	VUL WORD A ADDRESS
0	1	1	0	0	1	1	3	+1 to +10V RANGE
0	1	1	0	0	1	0	2	MSD "2"
1	0	0	0	0	1	0	B	VUL WORD B ADDRESS
0	1	1	0	1	0	1	5	SSD "5"
0	1	1	0	0	0	0	Ø	LSD "Ø"

Example 2. To program the T– (FALL TIME) to 99.9 ns, an entry of G19H99 ASCII is programmed in the following sequence;

BYTE BITS							ASCII	FUNCTION
7	6	5	4	3	2	1	CHARACTER	
1	0	0	0	1	1	1	G	FALL TIME WORD A ADDRESS
0	1	1	0	0	0	1	1	10 to 100 ns RANGE
0	1	1	1	0	0	1	9	MSD "9"
1	0	0	1	0	0	0	H	FALL TIME WORD B ADDRESS
0	1	1	1	0	0	1	9	SSD "9"
0	1	1	1	0	0	1	9	LSD "9"

Example 3. To program the REP RATE to 500 kHz, an entry of I35JØØ ASCII is programmed in the following sequence;

BYTE BITS							ASCII	FUNCTION
7	6	5	4	3	2	1	CHARACTER	
1	0	0	1	0	0	1	I	REP RATE WORD A ADDRESS
0	1	1	0	0	1	1	3	.1 to 1 MHz RANGE
0	1	1	0	1	0	1	5	MSD "5"
1	0	0	1	0	1	0	J	REP RATE WORD B ADDRESS
0	1	1	0	0	0	0	Ø	SSD "Ø"
0	1	1	0	0	0	0	Ø	LSD "Ø"

The word addresses are assigned ASCII Alpha Characters. Table 3-5 provides the ASCII Alpha and byte bit format for the 14 word addresses.

TABLE 3-5 WORD ADDRESS FORMAT

IEEE STD-488 PROGRAM BITS							ASCII	WORD
7	6	5	4	3	2	1	CHARACTER	ADDRESS
1	0	0	0	0	0	1	A	VUL A
1	0	0	0	0	1	0	B	VUL B
1	0	0	0	0	1	1	C	VLL A
1	0	0	0	1	0	0	D	VLL B
1	0	0	0	1	0	1	E	RISETIME A
1	0	0	0	1	1	0	F	RISETIME B
1	0	0	0	1	1	1	G	FALLTIME A

TABLE 3-5
WORD ADDRESS FORMAT (Cont)

IEEE STD-488 PROGRAM BITS 7	6	5	4	3	2	1	ASCII CHARACTER	WORD ADDRESS
1	0	0	1	0	0	0	H	FALLTIME B
1	0	0	1	0	0	1	I	REP RATE A
1	0	0	1	0	1	0	J	REP RATE B
1	0	0	1	0	1	1	K	DELAY A
1	0	0	1	1	0	0	L	DELAY B
1	0	0	1	1	0	1	M	WIDTH A
1	0	0	1	1	1	0	N	WIDTH B

The following tables 3-6 through 3-11 provide the ASCII numerical entered data for each word A 2nd Byte function(s).

TABLE 3-6
VUL WORD A FORMAT (ASCII A ADDRESS)

ASCII CHAR	FUNCTION(S)
Ø	−1V To −10V VUL RANGE
1	−.1V To −1V VUL RANGE
2	+.1V To +1V VUL RANGE
3	+1V To +10V VUL RANGE
4	−1V To −10V VUL RANGE
5	−.1V To −1V VUL RANGE
6	+.1V To +1V VUL RANGE
7	+1V To +10V VUL RANGE
8	EXT TRIG, −TRIG POL, −1V To −10V VUL RANGE
9	EXT TRIG, −TRIGPOL, −.1V To −1V VUL RANGE
:	EXT TRIG, −TRIG POL, +.1V To +1V VUL RANGE
;	EXT TRIG, −TRIG POL, +1V To +10V VUL RANGE
<	EXT TRIG, +TRIG POL, −1V To −10V VUL RANGE
=	EXT TRIG, +TRIG POL, −.1V To −1V VUL RANGE
>	EXT TRIG, +TRIG POL, +.1V To +1V VUL RANGE
?	EXT TRIG, +TRIG POL, +1V TO +10V VUL RANGE

TABLE 3-7
VLL WORD A FORMAT (ASCII C ADDRESS)

ASCII CHAR	FUNCTION(S)
Ø	−1V To −10V VLL RANGE
1	−.1V To −1V VLL RANGE
2	+.1V To +1V VLL RANGE
3	+1V To +10V VLL RANGE
4	COMPLEMENT, −1V To −10V VLL RANGE
5	COMPLEMENT, −.1V To −1V VLL RANGE
6	COMPLEMENT, +.1V To +1V VLL RANGE
7	COMPLEMENT, +1V To 10V VLL RANGE
8	OUTPUT OFF, 1V To −10V VLL RANGE
9	OUTPUT OFF, −.1V To −10V VLL RANGE
:	OUTPUT OFF, +.1V To +1V VLL RANGE

TABLE 3-7
VLL WORD A FORMAT (ASCII C ADDRESS) (Cont)

ASCII CHAR	FUNCTION(S)
;	OUTPUT OFF, +1V to 10V VLL RANGE
<	OUTPUT OFF, COMPLEMENT, −1 To −10V VLL
=	OUTPUT OFF, COMPLEMENT, −.1 To −1V VLL
>	OUTPUT OFF, COMPLEMENT, +.1V To +1V VLL
?	OUTPUT OFF, COMPLEMENT, +1V To +10V VLL

TABLE 3-8
RISE AND FALL TIME WORD A FORMAT
(ASCII E AND G ADDRESSES)

ASCII CHAR	FUNCTION(S)
Ø	5 – 10 ns RISE TIME RANGE
1	10 – 100 ns RISE TIME RANGE
2	100 – 1000 ns RISE TIME RANGE
3	1 – 10 μs RISE TIME RANGE
4	5 – 10 ns RISE TIME RANGE
5	10 – 100 ns RISE TIME RANGE
6	100 – 1000 ns RISE TIME RANGE
7	1 – 10 μs RISE TIME RANGE
8	5 – 10 ns RISE TIME RANGE
9	10 – 100 ns RISE TIME RANGE
:	100 – 1000 ns RISE TIME RANGE
;	1 – 10 μs RISE TIME RANGE
<	5 – 10 ns RISE TIME RANGE
=	10 – 100 ns RISE TIME RANGE
>	100 – 1000 ns RISE TIME RANGE
?	1 – 10 μs RISE TIME RANGE

NOTE: Rise and Fall times recognize only Rise Time Ranges.

TABLE 3-9
REP RATE WORD A FORMAT (ASCII I ADDRESS)

ASCII CHAR	FUNCTION(S)
Ø	UNDEFINED
1	10 – 50 MHz REP RATE RANGE
2	1 – 10 MHz REP RATE RANGE
3	.1 – 1 MHz REP RATE RANGE
4	10 – 100 kHz REP RATE RANGE
5	1 – 10 kHz REP RATE RANGE
6	.1 – 1 kHz REP RATE RANGE
7	10 – 100 Hz REP RATE RANGE
8	UNDEFINED
9	SYNC GATING, 10 – 50 MHz REP RATE RANGE
:	SYNC GATING, 1 – 10 MHz REP RATE RANGE
;	SYNC GATING, .1 – 1 MHz REP RATE RANGE
<	SYNC GATING, 10 – 100 kHz REP RATE RANGE
=	SYNC GATING, 1 – 10 kHz REP RATE RANGE
>	SYNC GATING, .1 – 1 kHz REP RATE RANGE
?	SYNC GATING, 10 – 100 Hz REP RATE RANGE

TABLE 3-10
DELAY WORD A FORMAT (ASCII K ADDRESS)

ASCII CHAR	FUNCTION(S)
Ø	UNDEFINED
1	10 – 100 ns DELAY RANGE
2	.1 – 1μs DELAY RANGE
3	1 – 10μs DELAY RANGE
4	10 – 100μs DELAY RANGE
5	.1 – 1 ms DELAY RANGE
6	1 – 10 ms DELAY RANGE
7	UNDEFINED
8	UNDEFINED
9	DOUBLE PULSE, 10 – 100 ns DELAY RANGE
:	DOUBLE PULSE, .1 – 1μs DELAY RANGE
;	DOUBLE PULSE, 1 – 10μs DELAY RANGE
<	DOUBLE PULSE, 10 – 100μs DELAY RANGE
=	DOUBLE PULSE, .1 – 1 ms DELAY RANGE
>	DOUBLE PULSE, 1 – 10 ms DELAY RANGE
?	UNDEFINED

TABLE 3-11
WIDTH WORD A FORMAT (ASCII M ADDRESS)

ASCII CHAR	FUNCTION(S)
Ø	UNDEFINED
1	10 – 100 ns WIDTH RANGE
2	.1 – 1 μs
3	1 – 10 μs
4	10 – 100 μs
5	.1 – 1 ms
6	1 – 10 ms
7	UNDEFINED
8	UNDEFINED
9	ASYNC GATING, 10 – 100 ns WIDTH RANGE
:	ASYNC GATING, .1 – 1 μs WIDTH RANGE
;	ASYNC GATING, 1 – 10 μs WIDTH RANGE
<	ASYNC GATING, 10 – 100 μs WIDTH RANGE
=	ASYNC GATING, .1 – 1 ms WIDTH RANGE
>	ASYNC GATING, 1 – 10 ms WIDTH RANGE
?	UNDEFINED

The Model 154-4 Pulse Generator may be controlled by a calculator that is IEEE STD-488 compatible. Following is a typical example using the Hewlett Packard HP9825 calculator as a controller device.

The HP9825 calculator is connected to the 154-4 Pulse Generator via the GPIB cable. Then the calculator and Pulse Generator are programmed as to their addresses by the rear panel address switches (7Ø1 address is used in this typical example, 7 being the calculator bus address and Ø1 being the Pulse Generator's address in decimal.

The calculator printout shown in Figure 3-4 depicts the commands entered of the typical program.

```
0: wrt 701,"A32B
 50C10D00E11F00G
 19H99I35J00K11L
 00M24N00";wait
 1000
1: wrt 701,"C01D
 25A31B25E19F99G
 11H00";wait
 1000
2: wrt 701,"I32J
 50";wait 1000
3: wrt 701,"M28H
 00";wait 1000
4: wrt 701,"E25F
 00";wait 1000
5: wrt 701,"G29H
 99";wait 1000
6: wrt 701,"E21F
 00";wait 1000
7: wrt 701,"G25H
 00";wait 1000
8: wrt 701,"E25F
 00";wait 1000
9: eto 0
*12415
```

FIGURE 3-4
TYPICAL HP9825 CALCULATOR PRINTOUT

Table 3-12 provides the step-by-step sequence of the typical program illustrated in Figure 3-4.

TABLE 3-12
TYPICAL PROGRAM HP9825

PROGRAM STEP	COMMAND	COMMENTS
0	Write ASCII "A32B5ØØC1ØDØ ØE11FØØG19H99I35JØØK11L ØØM24NØØ" to program Pulse Generator parameters, and wait 1 second.	Programmed the Pulse Generator to the following parameters; VUL +2.5ØV VUL + ØØØV RISE TIME 1Ø ns FALL TIME 99.9 ns

TABLE 3-12
TYPICAL PROGRAM HP9825
(Cont)

PROGRAM STEP	COMMAND	COMMENTS
0 (Cont)		REP RATE 5ØØ kHz DELAY 1Ø ns WIDTH 4ØØ ns.
1	Write ASCII "CØ1D25A31 B25E19F99G11HØØ" to change certain parameters, and wait 1 second.	Changed the following parameters; VLL to -1.25V VUL to +1.25V RISE TIME to 99.9 ns FALL TIME to 1Ø ns
2	Write ASCII "I32J5Ø" to change REP RATE parameter, and wait 1 second.	Change REP RATE to 25Ø kHz.
3	Write ASCII "M28NØØ to change WIDTH to 8ØØ ns, and wait 1 second.	Change WIDTH to 8ØØ ns.
4	Write ASCII "E25FØØ to change RISE TIME to 5ØØ ns, and wait 1 second.	Change RISE TIME to 5ØØ ns, FALL TIME will also change to 1ØØ ns because FALL TIME RANGE is set by the "E2" ASCII entry.
5	Write ASCII "G29H99", and wait 1 second.	Change FALL TIME to 999 ns.
6	Write ASCII "E21FØØ to change RISE TIME to 1ØØ ns, and wait 1 second.	Change RISE TIME to 1ØØ ns.
7	Write ASCII "G25HØØ to change FALL TIME to 5ØØ ns, and wait 1 second.	Change FALL TIME to 5ØØ ns.
8	Write ASCII "E25FØØ" to change RISE TIME to 5ØØ ns, and wait 1 second.	Change RISE TIME to 5ØØ ns.
9	Generate a go to "Ø" command to return to program step Ø.	Return to program step Ø. The *12415 printout indicates 12415 program locations remaining in the calculator's memory.

The Model 154-4 Pulse Generator may be controlled by the Systron-Donner Model 3530 Instrumentation Controller. Following is a typical example using the Model 3530 Instrumentation Controller as the controller device.

The Model 3530 Instrumentation Controller is connected to the 154-4 Pulse Generator via the GPIB cable. The Pulse Generator is assigned a Listen address of 0100101 (ASCII %) by the rear panel ADDRESS switches.

The following program is entered via the Model 3530 keyboard and will be displayed on it's CRT Display. Figure 3-5 depicts the CRT display.

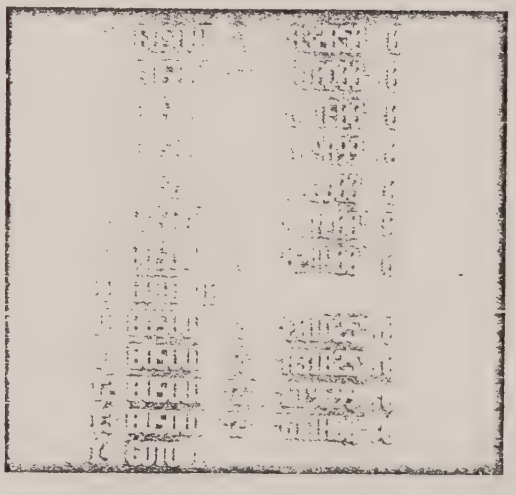
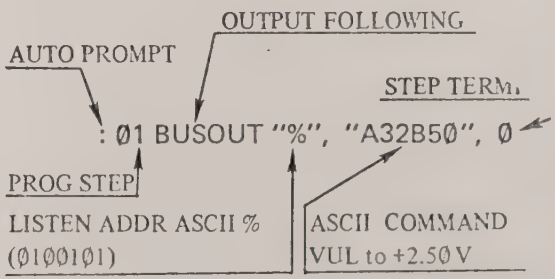


FIGURE 3-5 SD 3530 CRT DISPLAY OF A TYPICAL PROGRAM

The first line of the display is identified as to it's statements as follows;



This program will configure the 154-4 Pulse Generator into the following operational parameters.

REP RATE 2ØØ kHz (I32JØØ)
DELAY 1Ø ns (K11LØØ)
WIDTH 4ØØ ns (M24NØØ)
VUL Alternates between +2.5Ø V (A32B5Ø) and +1.25V (A31B25)
VLL Alternates between ØV (C1ØDØØ) and -1.25V (CØ1D25)
RISE TIME Alternates between 1Ø ns (E11FØØ) and 99.9 ns (E19F99)
FALL TIME Alternates between 99.9 ns (G19H99) and 1Ø ns (G11HØØ).

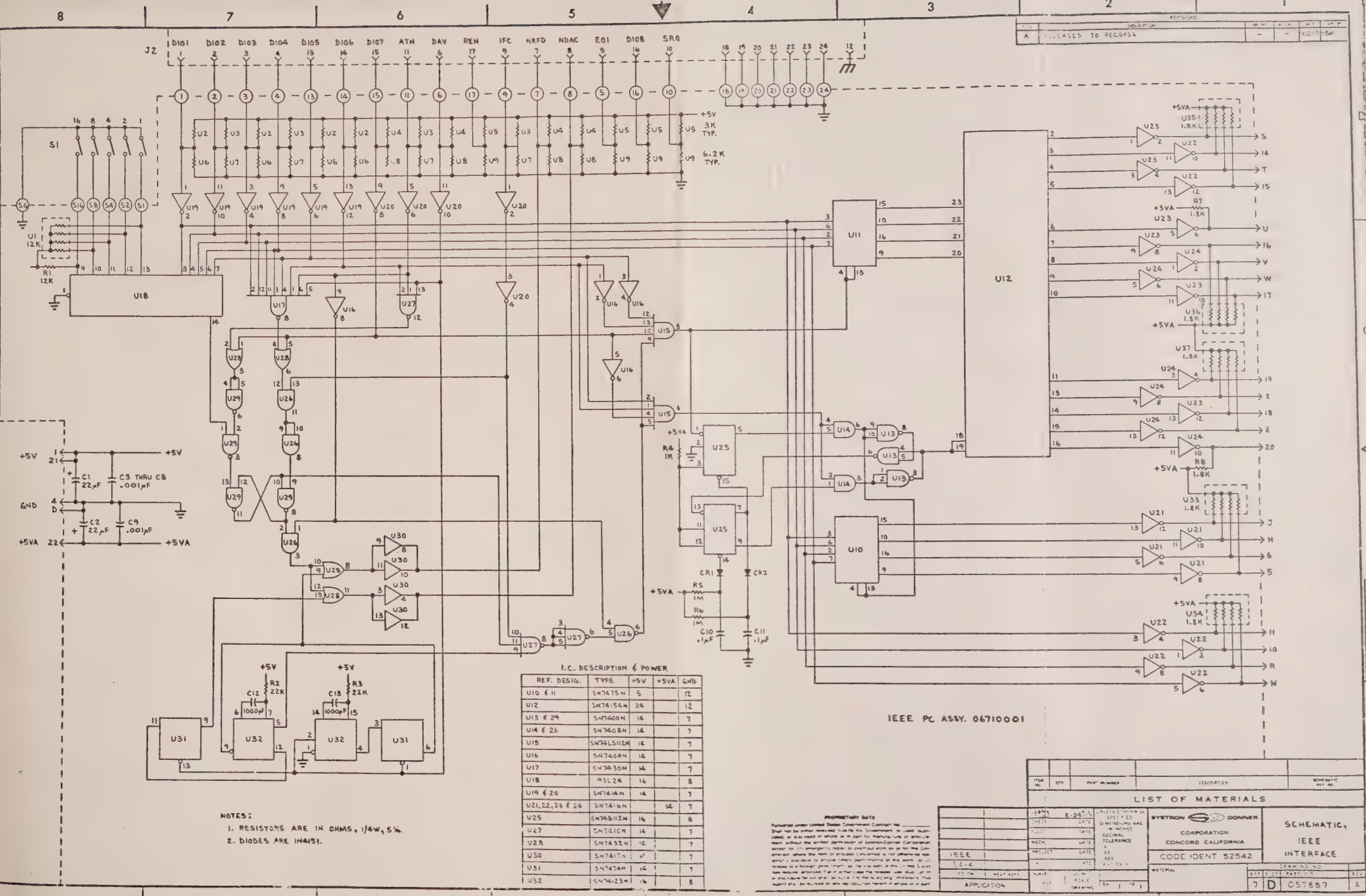
REPLACEABLE PARTS LIST

TITLE MODEL 154-4 IEEE INTERFACE PC ASSEMBLY

ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
		ASSEMBLY, IEEE PC	52542	06710001	06710001	1
		PC BOARD	52542	067100	067100	1
	C1	CAPACITOR, Tant 22 μF 10V	56289	196D226X9010JA1	103496	2
	C2	Same as C1				
	C3 thru C9	CAPACITOR, Cer .001 μF 50V	71590	CW15C102M	100251	7
	C10	CAPACITOR, Cer .1 μF 10V	71590	UK10-104	100120	2
	C11	Same as C10				
	C12	CAPACITOR, Mica 1000 pF 100V	72136	DM15FA102JO	10024301	2
	C13	Same as C12				
	CR1	DIODE	03508	1N4151	100385	2
	CR2	Same as CR1				
	R1	RESISTOR, CC 12k 1/4W 5%	01121	CB1235	101565	1
	R2	RESISTOR, CC 22k 1/4W 5%	01121	CB2235	101572	2
	R3	Same as R2				
	R4	RESISTOR, CC 1k 1/4W 5%	01121	CB1025	101569	1
	R5	RESISTOR, CC 1M 1/4W 5%	01121	CB1055	101605	2
	R6	Same as R5				
	R7	RESISTOR, CC 1.8k 1/4W 5%	01121	CB1825	101602	2
	R8	Same as R7				
	U1	RESISTOR Network 4 x 12k	52542	045008	045008	1
	U2 thru U5	RESISTOR Network 4 x 6.2k	52542	067116	067116	4
	U6 thru U9	RESISTOR Network 4 x 3k	52542	067115	067115	4
	U10	IC, TTL Quad Latch	01295	SN7475N	019710	2
	U11	Same as U10				
	U12	IC, TTL 4 - 16 line Decoder	01295	SN74154N	106640	1
	U13	IC, TTL Quad 2-In NAND	01295	SN7400N	019705	2

TITLE MODEL 154-4 IEEE INTERFACE PC ASSEMBLY (Cont)

ITEM	REF	COMPONENT DESCRIPTION	MFR'S CODE	MANUFACTURER'S PART NUMBER	SD STOCK NUMBER	T/Q
	U14	IC, TTL Quad 2-In AND	01295	SN7408N	103093	2
	U15	IC, TTL Dual 4-In AND	01295	SN74LS21N	103970	1
	U16	IC, TTL Hex Inverter	01295	SN7404N	025779	1
	U17	IC, TTL 8-In NAND	01295	SN7430N	025726	1
	U18	IC, TTL 5-Bit Comp.	07263	93L24PC	117020	1
	U19	IC, TTL Hex Inverter Schmitt	01295	SN7414N	117078	2
	U20	Same as U19				
	U21 thru U24	IC, TTL Hex Inverter	01295	SN7416N	045230	4
	U25	IC, TTL Dual J-K Flip-Flop	01295	SN74S112N	025786	1
	U26	Same as U14				
	U27	IC, TTL Triple 3-In NAND	01295	SN7410N	019706	1
	U28	IC, TTL Quad 2-In OR	01295	SN7432N	045257	1
	U29	Same as U13				
	U30	IC, TTL Hex Buffer	01295	SN7417N	106629	1
	U31	IC, TTL Dual D Flip-Flop	01295	SN7474N	025241	1
	U32	IC, TTL Dual One-Shot MVB	01295	SN74123N	045209	1
	U33 thru U37	RESISTOR Network 4 x 1.8k	52542	067114	067114	5



I.C. DESCRIPTION & POWER

REF. DESIG.	TYPE	+5V	+5VA	GND
U10 & 11	SN7475N	5		12
U12	SN74154N	24		12
U13 & 29	SN7400N	14		7
U14 & 26	SN7408N	14		7
U15	SN74LS112N	16		7
U16	SN7404N	14		7
U17	SN74S30N	14		7
U18	93L24	16		8
U19 & 20	SN7414N	14		7
U21,22,23 & 24	SN7416N		14	7
U25	SN74S112N	16		8
U27	SN7410N	14		7
U28	SN7432N	14		7
U30	SN7417N	14		7
U31	SN7474N	14		7
U32	SN74123N	16		8

NOTES:
1. RESISTORS ARE IN OHMS, 1/4W, 5%.
2. DIODES ARE IN4151.

REVISIONS				
A	RELEASED TO RECORDS	–	–	

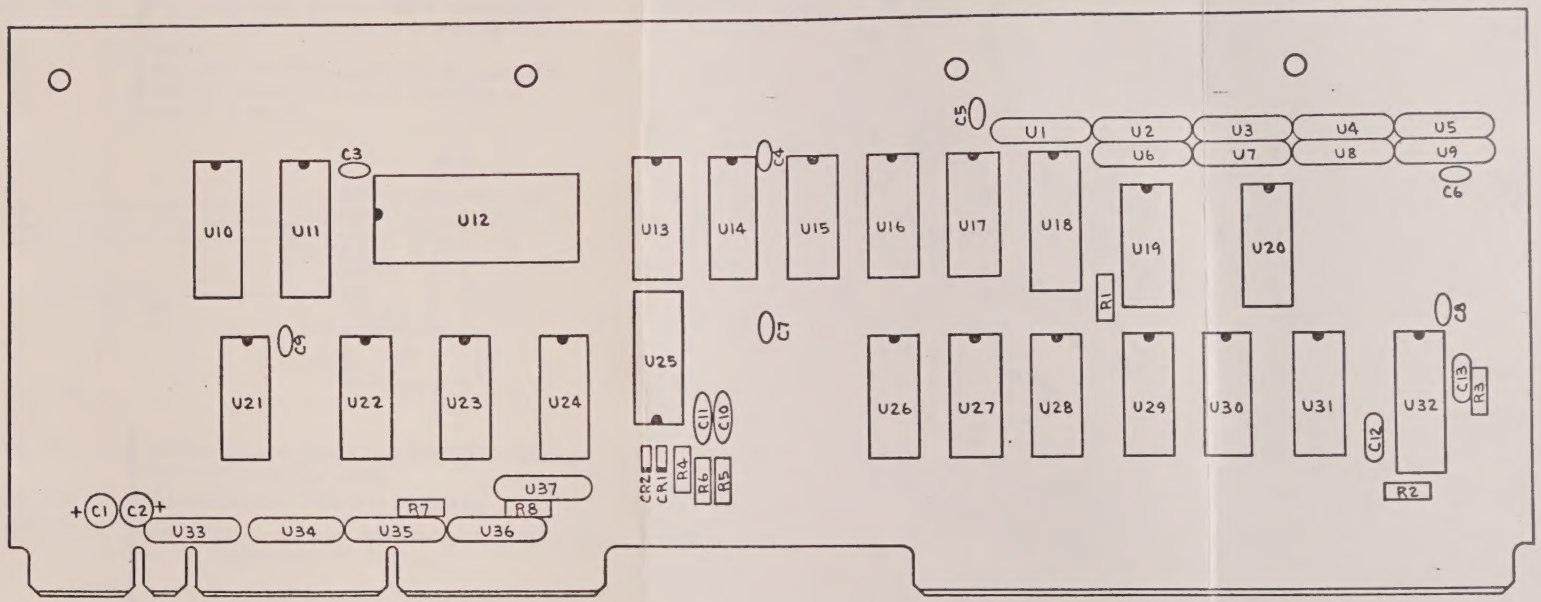
LIST OF MATERIALS

ITEM NO.	QTY	PART NUMBER	DESCRIPTION	SCHEMATIC REF. NO.

DRAWN	8-24	SPECIFIED DIMENSIONS ARE IN INCHES	BYSTRON DONNER CORPORATION CONCORD CALIFORNIA
CHECK	DATE	DECIMAL TOLERANCE	CODE IDENT 52542
MECH	DATE	.X ±.1	SCHEMATIC, IEEE INTERFACE
PROJECT	DATE	.XX ±.03	
IEEE 5E-4		.XXX ±.015	
APPLICATION	NEXT ASSY	SCALE	DRAWING
MATERIAL			DRAWING NO. 7 D 057887 A

PROPRIETARY DATA

REVISIONS					
REV	DESCRIPTION	SAR. NO.	ECO NO.	DATE	APP. BY



ITEM NO.	QTY	PART NUMBER	DESCRIPTION	SCHEMATIC REF. NO.

LIST OF MATERIALS

PROPRIETARY DATA

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154-4					
USED ON	NEXT ASSY				
APPLICATION					

DRAWN	9-19-77 DATE	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DECIMAL TOLERANCE .X ±.1 .XX ±.01 .XXX ±.005 ANGLES ± 1°	SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA
CHECK	DATE		
ELECT.	DATE		
MECH.	DATE		
PROJECT	DATE		
QA	DATE		
SCALE 2:1	DO NOT SCALE DRAWING	SH 1 OF 2	

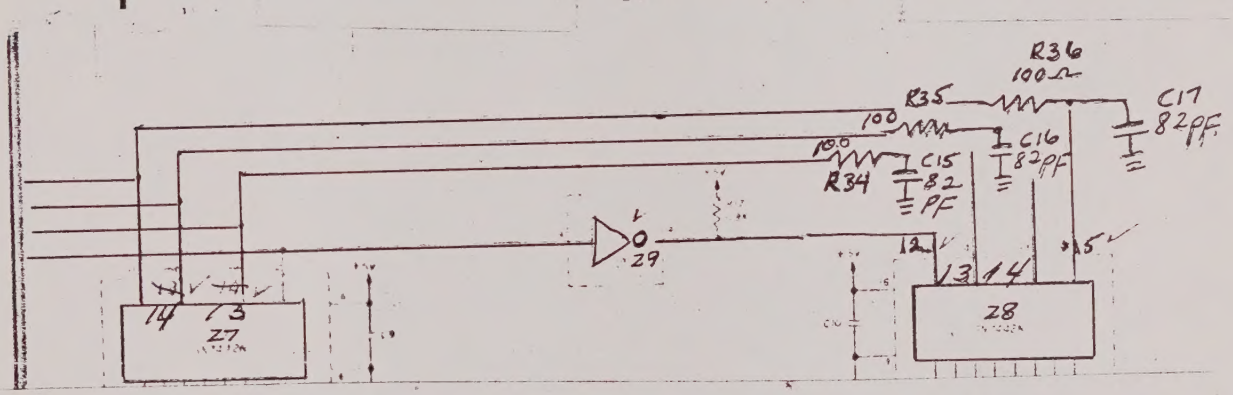
ASSEMBLY, IEEE BOARD

CODE IDENT. 52542

MATERIAL

DRAWING NO.			
REF	SIZE	PART NO.	REV
	C	06710001	A

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
4477	8-8-73	40000-483	Correct schematic as shown below. Z9 as inverter and Z7. Z8 pins assignment to conform with board layout. Add R34, R35, R36 resistors, 100 ohms and C15, C16, C17 capacitors, 82 pF on input lines of Z8, pins 13, 14 and 15.



4529	9-21-73	40000-417	Add fuse 1.5 amp, pig-tail type, P/N15470-100 in series from point N to lamps.
4556	10-18-73	40000-438	Change Q30 from DP59-0 to 2N2904A.
4713	4-9-74	40000-417	Change note 4 from All diodes are IRC 20A1 to All diodes are SC SS1m.

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